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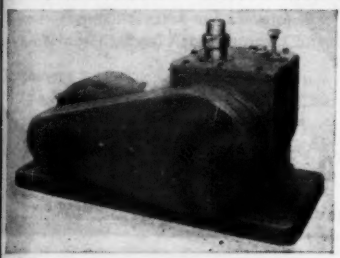

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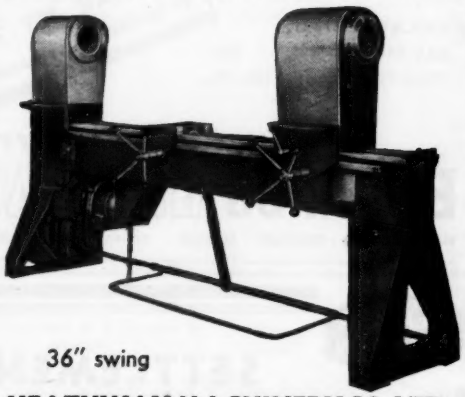

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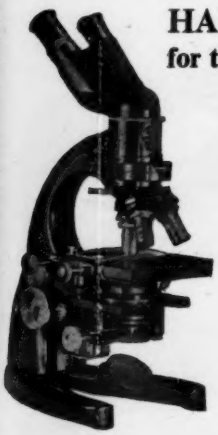

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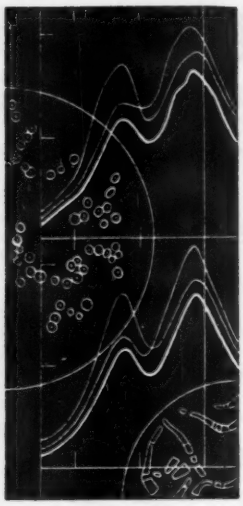

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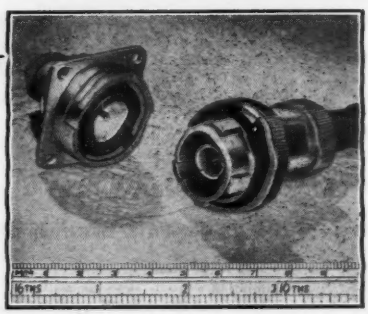

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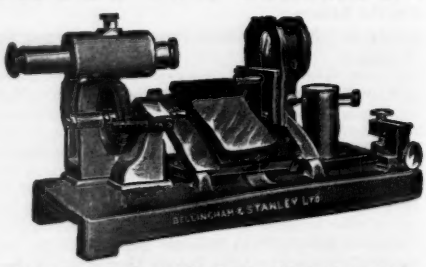

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THE FINANCING OF UNIVERSITY RESEARCH

AT the second session of the Home Universities Conference a discussion on the financing of research in universities by outside bodies started from the data provided by a report on the relations between scientific research in the universities and industrial research in Great Britain which Dr. V. E. Cosslett had edited for the Association of University Teachers. It was several months, however, before the report was actually published* by the International Association of University Professors and Lecturers, with the assistance of the United Nations Educational, Scientific and Cultural Organization. In the meantime, in the debates on the Department of Scientific and Industrial Research Bill, both the control and adequacy of government research in Britain have come under fresh review, and in particular the adequacy of Government support of research in the universities was raised by Lord Cherwell. Prof. S. H. Beer's book on "Treasury Control", while concerned with the co-ordination of financial and economic policy generally in Great Britain, raises some fresh issues in regard to the financial control of research and of such activities as those of the universities, where accounting on a year-to-year basis may well lead to inefficiency and where the quinquennial principle has big advantages.

Since that book was published, a further report from the Public Accounts Committee has argued that improvements in university procedure and methods affecting administration and contract practice are desirable in order to avoid waste and extravagance; and the preliminary estimates resulting from a survey of British investment in research and technical development made by the Department of Scientific and Industrial Research have been presented by Mr. Ernest Rudd in a paper to the British Association read at Sheffield on September 4. The figures were given in comparison with similar estimates for the United States and following the estimates made in the spring of last year by Sir Harold Hartley, and they raise once more the question of the adequacy of expenditure in Britain on research. Its distribution has also been challenged in connexion with the Department of Scientific and Industrial Research as well as, on occasion, in connexion with the development of nuclear energy and automation.

These three aspects of the national research spectrum cannot be sharply separated. If research—at the universities, in industry or in the government services—is not wisely directed, the effort is not likely to be distributed wisely, or if well distributed to yield the maximum return. If control is too rigid and exercised without regard to the nature of the work or the conditions in which scientific work is most fruitful, we are unlikely to attract the creative minds that are needed or to gain full advantage from the expenditure sanctioned. To devise the controls which provide the maximum freedom and stimulus for those engaged in research, and ensure that adequate resources are at their disposal, while at the same time seeing that the nation's available resources for research are deployed to the best advantage, so far as can reasonably be judged, and that there is no unjustifiable overlapping or waste, is a difficult task demanding judgment of a high order as well as insight and imagination and wide knowledge and experience.

The report of scientific research in universities and industry which was discussed at the Home Universities Conference shows how delicate is the balance, and it was obvious at that discussion that the universities themselves took a very wide public view of the problem. The report helps to supply the knowledge of the detailed ways in which university laboratories maintain direct contact with those of industrial laboratories which, apart from evidence obtained from industry in an inquiry made by the Manchester Joint Research Council, is largely lacking. After briefly outlining the organization of research in Great Britain, it describes the detailed relations of university and industrial research before considering the difficult problems which any great increase in the industrial research undertaken in university departments or by individual members of their staffs raises for the universities.

The inquiry was limited to research in the natural sciences, including engineering and technology, but excluding medical research. In these fields the inquiry showed that only 6 per cent of research projects in the universities undertaken by members of their academic staffs are financed wholly, and 32 per cent partly, from outside sources, and about half these projects appear to be initiated from outside sources. In all, about 20 per cent of the resources of scientific and technological departments in British universities are engaged on work of direct interest to industry, and this figure is equivalent roughly to 10 per cent of their total budgets and to 5 per cent of the university budget as a whole. This figure includes the support received from research associations, but not that received from other Government agencies, which may total another 7 per cent of the university income with a further 2 per cent coming from the charitable foundations, such as the Nuffield Foundation, and learned societies. Moreover, general opinion was overwhelmingly in favour of this contact with industry: 82 per cent of those replying thought it was of value to their own studies and only 23 per cent thought that it conflicted with their research interests; 86 per cent agreed that it was in the interests of the department as a whole.

This total of some 14 per cent of university income, however, represents about 25 per cent of the total income of the scientific and technological departments, and may amount to as much as 50 per cent

* The Relations Between Scientific Research in the Universities and Industrial Research: a Report on Conditions in Great Britain. Edited by Dr. V. E. Cosslett. Pp. vii+187. (London: International Association of University Professors and Lecturers, 1956.) 15s.

of their funds for research. It should be noted that, in contrast to the position in the United States, most of these projects have been put forward on the initiative of the university worker. Apart from the present large pre-occupation with nuclear research, government grants to British universities have been primarily for fundamental investigations and are not related to immediate industrial needs, though this is not to say that in making a grant a research council may not have some longer-term national need in mind. The system, however, appears to be working well. But apart from these annual grants, the capital requirements of a university are likely to continue to be great, and even if private and industrial benefactions increase their support, the State will probably in future provide the major proportion of the capital as well as the current finance for university research.

Before considering the particular issue which caused most concern at the Home Universities Conference, the great variety of part-time, occasional and informal exchange of staff between industry and the universities should be noted. The usual method of getting specialist help from industrial scientists by university departments has been to appoint them as part-time lecturers. Direct interchange as yet is only on a small scale; but there has been a growing tendency since 1945 to increase the intercourse between industrial and university scientists, and the interchange of staff at all levels is a factor of the greatest importance in breaking down the tendency to look down upon industrial research. There are also many other varied ways in which intercourse between the universities and industry occurs in scientific and technological matters, and in general the report suggests that the universities should not be called upon to devote more of their resources to industrial problems. Some room for improvement may well remain, and in particular the relations of the universities to the research associations appear to merit closer examination.

While there are strong forces working against the establishment of closer relations between research associations and university departments, in preference to direct connexions between the latter and private firms, it has been argued that connexions between industry and the universities should be increasingly channelled through the research associations. This is quite apart from the educational functions of the latter, though those functions might be encouraged by such a development, which could well have the effect of ensuring that eminent university scientists are only called upon as consultants to industry for very specialized problems. On the other hand, the effectiveness of particular research associations as research organizations requires critical consideration before such a step is taken for any particular industry. On the basis of the general measure of support which industry gives to research, as indicated by Mr. Rudd's survey, little confidence can be felt that industry will simultaneously increase still further its benefactions to the universities.

The main problem at the present time arises from the increasing tendency during and since the War for government departments and industrial concerns to call on the universities for help in solving scientific and technological problems. This can result in the larger part of the research work of a particular university department being in the form of short-term contracts, and unless there is some degree of central control in a university, individual departments can in this way expand so as to throw out both the normal balance of research and teaching and that between fundamental and applied research. Even to devise appropriate methods of control within the university involves a number of delicate problems if the conditions for fruitful creative work are to be preserved. These are considered in the report, which seeks, however, rather to elucidate the principles that should guide policy and practice rather than to elaborate a precise system.

The report takes as the basis for a sound policy that a rough balance should be preserved between teaching and research in the university as a whole and in each department, and a similar balance between internally and externally financed research. As a first principle, adequate resources should be available within each university to finance the main lines of research in each department, so that appeals to outside bodies are for extension only and are never allowed to become a dominant and controlling factor. Universities best serve the community which supports them by undertaking fundamental investigation of natural phenomena rather than by working on problems of more or less immediate interest to industry. Accordingly, industrial and other private bodies can best support the universities by making unrestricted grants to their general funds, instead of earmarked grants for particular investigations or actual research contracts. The best place for applied research is usually the research association or the individual firm, and the report suggests that it would be well to accept as a limit for scientific departments that not more than one quarter of the total budget should be derived from outside sources.

The report does not consider whether or not applied research is appropriately carried on at the colleges of technology, though clearly the same considerations apply there as with the university departments of technology. Agreement, moreover, is desirable among universities as to the broad criteria to be used in assessing research contracts and the terms under which contracts would be accepted; and the proposals put forward in the report on the sponsored research policy of colleges and universities, prepared by a committee of the American Council on Education, are regarded as providing a reasonable basis for discussion. For those very large projects demanding installations so costly that they would seriously disturb the balance between a department and the rest of a university, the best solution is regarded as the establishment of a special research station with State funds which would be staffed and operated either by the State or by several universities in co-operation.

The difference in outlook between private industrial interests, with the natural desire to reap a quick advantage from priority in use, and the community

of scholarship of the university is at the root of one of the chief arguments for strictly limiting the volume of research undertaken by universities and the conditions for acceptance. In time of peace, work carried out in academic laboratories should be free of restrictions on publication, and work involving industrial secrets should be carried out in industry itself, while secret work under government contract has only a place in a university under conditions of emergency and should be transferred to a State establishment as soon as facilities can be made available.

The report does not discuss exhaustively these and other problems which are causing increasing concern in the universities. But it stresses the need for wider recognition of the problems with which the universities and their scientific and technological departments are confronted in their relations with industry and with Government. It argues that more detailed official investigation is required if we are to work out solutions appropriate to the structure of research in Britain, and in particular suggests that we should develop still further the role of the research associations as a buffer, or filter between industry and the universities.

PAST ZOOLOGISTS AND PRESENT GENETICS

Portraits from Memory

Recollections of a Zoologist. By Prof. Richard B. Goldschmidt. Pp. x+181+4 plates. (Seattle: University of Washington Press, 1956.) 3.50 dollars.

Theoretical Genetics

By Prof. Richard B. Goldschmidt. Pp. x+563. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1955.) 64*s*. net.

PROF. RICHARD B. GOLDSCHMIDT, doyen of the genetical world and president of the most recent International Congress of Genetics, began his scientific life in Germany before genetics, as we know it, came to birth with this century. He can look back to a different era in zoology when the foundations were being laid for what have now grown into virtually new sciences; and he can recount personal reminiscences of men—the Hertwigs, Boveri, Roux and Spemann, to list but a few—who can be little more than names in books to most of us nowadays. In "Portraits from Memory" he looks back over the years and, with a wealth of delightfully told anecdote, brings to life for us this vanished world. We can sit in at a doctoral examination at Heidelberg, where the candidate attends resplendent, if uncomfortable, in tails and silk hat while professorial jealousies work themselves out; we can see the Kaiser fidgeting his way through a lecture by Richard Hertwig on sex determination; and we can share the triumph of the discovery of syphilis spirochætes and the heartache of its reception. At the end, names are mere names to us no longer. They are living men, brought to life by a portrayal of their foibles and jealousies as well as their talents and their greatness. We may feel that at times their pictures emerge in perhaps over-stark contrast of black and white, for one of the charms of the book is the way in which it relives Prof. Goldschmidt's own youthful enthusiasms; but our only regret can be that the portraits are not even more numerous. One reader at least would very much have liked to see Correns and Bauer, for example, through Prof. Goldschmidt's eyes, for portraits of the early geneticists are all too rare.

In "Theoretical Genetics" Prof. Goldschmidt turns to a totally different subject—the basic theoretical problems of genetics as he sees the science. It should be made clear at the outset that his coverage is by no means complete. Population genetics, genetic systems, chromosome mechanics, variability and selection, for example, are not dealt with. Rather, he concentrates on a discussion of the genetic materials and the way they do their work: on entities and processes at the cell-level. His approach is essentially physiological and developmental, and his treatment is, as we have come to expect of him, forthright and provocative. Nothing is left unchallenged, although one feels that the challenge is not always either effective or justified. It is generally accepted, for example, as the first principle of genetics that the phenotype is the product of reaction of the genotype and the environment. First, restating this to read ". . . that orderly development is the result of an interplay between genic activity and environment", Goldschmidt goes on to give his opinion that it "is a completely misleading statement in spite of its apparent truth", adding ". . . if we consider the organism within the environment to which it is adapted, development is completely controlled by the genic material". But surely, in the absence of any definition and criterion of adaptation, which is not supplied, this begs the question; and in any event, the statement cannot be true in any final sense, for it has been repeatedly shown that similar structures on the same individual may differ in ways attributable only to chance upsets themselves scarcely referable to differences in the genotype.

Now, evidence can be obtained about materials of genetical importance from three sources: by their direct observation, microscopically, chemically, and so on; by their behaviour in hereditary transmission; and by their action in producing their effects. Each kind of evidence has its own value and its limitations. Our task is not to set one against the other, but to combine them towards a fuller understanding of organization and action. It is, in a sense, the familiar and often complicated biological problem of elucidating and relating structure and function, appearing in a new setting. This emerges clearly from Goldschmidt's section on the nature of the genetic material where he analyses the concept of the gene—a term which he does not like and wishes to abandon. He was, in fact, the first to point out that the classical notion of the gene was too simple, and his latest discussion will be read with interest. He also discusses whether the deoxyribonucleic acid or the protein fraction of the chromosomes is the true genetic material, and finally favours the protein. His reasons for doing so are not clear, and indeed one wonders whether basically it is not simply because, as emerges much later in the book, he assumes that the genic material must act by producing replicas of itself, the agents of gene action being in fact proteins. This assumption itself is challengable, and indeed the very question he starts with is not obviously the right one. Both fractions would appear to be essential, so that one is led rather to ask what each does and how they com-

plement one another in the joint function of reproduction and action.

Moving to the less-understood cytoplasm, the water becomes even deeper. Goldschmidt clearly has an intense dislike of the notion of the plasmagene—the "wobbly concept" as he calls it—and he is anxious to do away with it. His attempts will certainly not carry universal conviction. He rules out kappa particles, even as a model, on the grounds that kappa is a virus—deadly not to those carrying it but to those which do not—without ever discussing the criteria which distinguish virus and plasmagene, or analysing the deeper significance of these criteria. Plastids are likened to organisms and their evidence faded out; and the existence of information about cytoplasmic segregation in plants is mentioned, only to be dismissed on the grounds that, thinking of cytoplasmic differentiation and its obvious difference from genetic segregation, the zoologist will be "skeptical". The notion of the plasmagene may well have been abused; but it was introduced to meet a need, and it is not to be so lightly rubbed out. The inference of "self-propelling processes" and "steady states" on physiological grounds is no alternative to the postulation of self-producing particles in the cytoplasm from the evidence of transmission. One does not prove the other, but it equally does not replace it. Indeed, we are led to ask what basis the controlled self-impelling process has. Is it structural? Is it, in fact, some kind of plasmagene?

The cytoplasm has a structure and organization different from that of the nucleus. It does a different job. It appears more heterogeneous, and its parts may well have come together in a different way. We must expect these parts to be differently related one to another and to the nucleus. In short, they pose the problem of structure and function in a new and perhaps even more difficult way. We shall need all the evidence we can gain, whatever its source, and we shall need to clarify our concepts if we are to arrive at the answer. The history of the gene concept has surely shown us that the physiological does not replace the mechanical and that deeper understanding comes when we try, not to oppose, but to relate particle and process, structure and action, form and function.

One could go on through the full five hundred pages of the book objecting and arguing almost endlessly, and by so doing attesting, I believe, to Prof. Goldschmidt's success in at least one of his chief aims. "Theoretical Genetics" is avowedly for the specialist. It presents a point of view on controversial subjects, and a point of view to stir fruitful discussion rather than to secure facile agreement. It collects together an imposing amount of fact and opinion, though unfortunately not every author's views are correctly reported or their references correctly cited. It might have benefited by condensation, for there are lengthy digressions; and in any event the treatment is so exhaustive as at times to be exhausting. Cross-references, too, would have helped where evidence is touched on before being given in detail, and where a subject is taken up again on later occasions. It remains, however, a book which should be widely read among geneticists. Its arguments and conclusions will arouse disagreement, often deep disagreement; but in disagreeing we can scarcely fail to be challenged into critical examination of much that we too frequently take for granted.

Kenneth Mather

THE JEWS IN ANCIENT AND MODERN TIMES

This is Israel

Palestine—Yesterday, Today and Tomorrow. By Dr. Theodore Huebener and Dr. Carl Hermann Voss. Pp. x+166+8 plates. (New York: Philosophical Library, 1956.) 3.75 dollars.

THE first half of this little volume is devoted to a historical sketch. "Every effort has been made to treat the various religious and political issues fairly and objectively", states the wrapper, and the reader will endorse the claim. Remarkably succinct and lucid is the survey covering the Biblical period (with due use of modern scholarship), subjugation by Rome, the ministry of Jesus and rise of Christianity, the rise of Islam and the comparatively peaceful rule of successive Islam empires, the Crusades with massacres alike of Jews and Moslems, the successive Turkish invasions, the First World War, the Balfour Declaration (1917), the British Mandate, the war between Arabs and Jews, and the establishment of the State of Israel in 1948. This portion of the work would be usefully supplemented by more maps.

The remainder of the volume deals not with the political but with the cultural record. The authors touch on the preparation of the two Talmuds, building on Old Testament commentary a rule of life. Two dissenting Jewish bodies are mentioned: the Samaritans (a tiny group now fallen under Arab rule), and the Karaites, a scattered Jewish brotherhood who endeavour to follow literally the Old Testament rather than Talmudic and subsequent commentators. The linking is noted in Jewish consciousness throughout the centuries of the land of Israel with the sense of an Israelite religious mission. The authors mention also the friendly understanding reached in 1918 between the Jewish leader Weizmann and King Hussein of the Hedjaz and confirmed the following year by his son and heir, the Emir Feisul—an understanding not encouraged by British authority, who unfortunately deprecated also the beginnings of Israeli–Transjordan co-operation prior to the British transformation of Transjordan into the State of Jordan.

The story of Zionist aspiration and achievement is told through accounts of a few of the great protagonists of the drama. Very interesting is the account of the movement "Back to the Land" initiated by Aaron David Gordon—"this refined, sensitive, vegetarian non-resistant" from Russia, whose settlement, started in 1909 with twelve young pioneers at Dagania near the Sea of Galilee, still persists, transformed to fertility. "Today", state the authors, "over one fifth of the people of Israel live on the land and till the soil". Theodore Herzl, of course, bulks large in the story of Israel, as does Eliezer ben Yehuda, who established and enlarged the modern Hebrew language, though unfortunately too early to emulate Kemal Atatürk by conforming the language to Western Latin script. The moving and inspiring story is told of the American Henrietta Szold, founder of the hospital organization throughout Israel and supporter of the educational work. Space has not been found for mention of Aude Wingate, the great British officer who brought comfort to many in Israel, nor of Martin Buber, the noble contemporary Israeli philosopher of individual responsibility. The great Hadassah hospital, the Hebrew University of Jerusalem, the scientific research Institute at

Rehovot and the constantly extending Technion at Haifa are, of course, mentioned. The work of all continues and grows, though the splendid buildings and equipment of the two first-named are to-day held sterile and unused by the State of Jordan. The amazing transformation of the desert Negev is also described.

Undoubtedly those who so devotedly and cheerfully labour to create the new Israel are sustained by the sense that they are path-finders for future generations not only in Israel but even over the whole world. Recalling how almost each one has, personally or through others beloved, suffered from the mistakes of the world behind us, who will call their aspiration priggish or even unreasonable?

DOROTHEA WALEY SINGER

CONTROL OF HUMAN CONDUCT

Social Control

By Dr. Joseph S. Roucek and Associates. Second edition. Pp. viii+603. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: Macmillan and Co., Ltd., 1956.) 50*s*. net.

THIS is yet another of the immense array of introductory texts produced in the United States which deal with various aspects of the study of sociology. It opens by restating the familiar theme of increases of crime and chaos in the post-war world which leads to the conclusion that, "if mankind is ever to be free from fear of aggression . . ., the wise control of human conduct is far more significant than any degree of mastery of the world of nature". This is quite unexceptionable, if somewhat trite. But, unfortunately, we may be misled too readily by the suggestion that the book attempts to deal with the intimidating problem as to how "wise control" is to be exercised. Social control is quickly redefined in the opening paragraphs as the "processes, planned or unplanned, by which individuals are taught, persuaded or compelled to conform to the usages or life-values of groups", which begs the whole question as to whether these usages, etc., can be continued further into the twentieth century without undue loss, or even peril. Furthermore, the most important issue latent in this formulation, as to the extent to which social control can be effectively planned and executed—even within this narrow context—is given only the briefest and most superficial treatment.

For the most part, the book provides a very general and at times somewhat dogmatic account of the social and psychological influences which shape our personalities and our societies in ways we tend to take for granted. The social 'conditioning' of personality, the leadership process, propaganda and similar topics are all passed in review without any general conclusion being reached. The final chapter on "Social Control and the Atom Bomb" is characterized by a deep pessimism: the last sentence in the book is that "the doom of mankind may already have been decreed". Whether this is intended as a judgment based on mature reflexion on the problems of social control, or whether it is a merely irresponsible or somewhat unconsidered remark, is not clear. But it can only be regretted that the brief and somewhat naïve section on economic and social planning could not have been greatly expanded, so as to deal with the basic problem of "wise control" which is posed but not discussed, let alone resolved.

It is recognized that some kinds of public planning and administration are successful, and have provided the foundations on which the modern urbanized way of life has been based. But it has proved exceedingly difficult to widen and strengthen these foundations, and the fact has not been recognized that the time has come when precise questions as to how and why must be put, with all the intellectual and moral courage that we can command. T. S. SIMEY

MODERN ASTRONOMICAL OPTICS

Proceedings of a Symposium on Astronomical Optics and Related Subjects

Held in the University of Manchester, April 19th–22nd, 1955. Ed. by Prof. Zdenek Kopal. Pp. xv+428. (Amsterdam: North-Holland Publishing Co.; New York: Interscience Publishers, Inc., 1956.) 45 guilders; 90*s*.

THE contents of this impressive volume cover a very wide field of problems ranging from abstract considerations on information theory to questions of a very practical nature concerning dye filters, interferometers, etc. But they all have one common denominator: they refer to problems characteristic of modern astronomy which, extending its observations to invisible objects—that is, to very faint and distant stars and star-systems—has to develop new methods of registering and analysing the observable data. These again give rise to quite novel difficulties.

Modern electronic devices make it possible, for example, to measure with photomultipliers, attached to the 200-in. telescope at Palomar, the light intensity of a star of not much less than magnitude 24, which would correspond to observing Sirius as far away from us as one million parsecs; it should be possible to measure even fainter stars. However, how will the observer locate such a star in the photometer if this star is invisible—that is, it cannot even be located on a photographic plate? Similarly, when formerly the observer wished to make a spectral investigation of a star, he produced an image of this star on the slit of a spectrograph, keeping during the exposure the star image steady on the slit. For faint objects this is no longer possible. So different devices have to be developed to enable monochromatic analysis of very faint invisible light sources. The last chapter, on filter photography of thin films, is thus devoted to problems of this kind.

Since a great refinement is a common necessary feature of all observations, all disturbing effects, like the scintillation of star images, have to be carefully analysed to eliminate their influence; Chapter 5 deals with resolution problems and scintillation. It becomes thus also clear why the information theory plays an important part. The actually observed effects frequently appear to be scarcely related to what the observers actually wish to find out; thus a minute analysis of the content of information in the observed data is needed.

This book is a rich source of information for every modern astronomer. An astronomer brought up in the tradition of spherical astronomy and celestial mechanics may feel a bit bewildered, like a connoisseur of classical music or painting listening to music by Hindemith or looking at pictures by Braque.

E. FINLAY-FREUNDLICH

Flow of Gases Through Porous Media

By Dr. P. C. Carman. Pp. ix+182. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1956.) 30*s*.

IT is some twenty years since Dr. P. C. Carman suggested the permeability method for the measurement of the surface area of fine particles such as cement. During these years the range of interest in the flow of fluids through porous media has increased considerably, and in this book he has presented a concise account of the subject, including the recent work on gas diffusion and separation.

The primary aim of the book is to present a quantitative account of the flow process when a gas enters or passes through porous media. The theme of the book is a discussion of the Kozeny–Carman equation for the flow in such systems, and one of the great merits of the text is that the writer has explained in detail the limitations of this approach and the consequent reasons for its failure in some instances.

Chapter 1 contains a formal presentation of the Carman equation as developed for unconsolidated media, and in Chapter 4 the application of this equation for measurement of particle surface is given. Of greater interest is the discussion in Chapter 2 of the influence of abnormal pore texture, the distribution of pore size and the problem of flow through consolidated media.

Chapter 3 covers slip flow and Knudsen flow and a short account of diffusion in porous media. Chapters 5 and 6 contain an account of more recent work on the flow of sorbable gases, leading to a discussion on surface diffusion and gas separation processes. Finally, Chapter 7 covers the transition zone to turbulent flow and an introduction to the conditions of fluidization.

This is a scholarly text written by an acknowledged authority in this field, and it will be welcomed by all whose activities so much as touch on this subject. The book as written has rather a terse style, and a general introduction, particularly to Chapter 1, would have been of value to the more general reader.

Reduction with Complex Metal Hydrides

By Norman G. Gaylord. Pp. xvi+1046. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1956.) 15 dollars.

THIS book, which started in 1951 as a review article on reductions with lithium aluminium hydride, is a comprehensive survey of the preparation, properties and uses of all the complex metal hydrides known up to the end of 1953. The reactions of these hydrides with inorganic as well as organic compounds are described. Then there is a useful general discussion of reduction of organic compounds with complex metal hydrides: stereochemical features and analogies with Grignard reactions are reviewed. Each functional group has a chapter to itself, with full references and tables giving substance reduced, product and yield. In addition, the more interesting cases are described in fair detail with supporting formulæ and reaction schemes.

A very considerable number of the compounds mentioned are from the chemistry of natural products. The collecting together of so many examples will be of particular value to those investigating steroids. The information is set out in a very acceptable form, easy to follow. There are very few mistakes, either chemical or typographical. It is a pity that throughout the book aluminium is spelt aluminum.

The book of this size and scope, which could so easily have been little more than a catalogue, is interesting and informative. It gives a balanced view of this extraordinarily fertile field and will doubtless stimulate further research in both inorganic and organic chemistry. E. E. Turner

Theory of Combustion Instability in Liquid Propellant Rocket Motors

By Luigi Crocco and Sin-i Cheng. (Agardograph, No. 8.) Pp. viii+200. (London: Butterworths Scientific Publications; New York: Interscience Publishers, Inc., 1956. Published for and on behalf of the Advisory Group for Aeronautical Research and Development, North Atlantic Treaty Organization.) 37*s*. 6*d*.; 5.25 dollars.

A LIQUID-PROPELLANT rocket motor is a complicated system in which fuel and oxidizer are pumped through a perforated injector plate, combined in a combustion chamber and accelerated to supersonic exit-speeds in a Laval nozzle. This book is a compendium of theoretical considerations (related only perfunctorily to experiment) on the problem of understanding and learning to avoid such instabilities of the system as lead to oscillations of an organized character in the pressure and temperature in the combustion chamber; these can be responsible for mechanical or thermal failure of components. 'Chugging', or low-frequency instability, is ascribed to an interaction between the time-lag for change in injection-rate to produce changes in combustion-rate, the time-lag for these changes to evacuate the chamber to a different pressure, and the time-lag for this to affect the injection-rate through the equations of the pumping system. The equations are treated, in addition, for the case of a servo-mechanical control, which feeds back signals from the combustion chamber into the fuel flow-line, and for the case when the combustion time-lag itself varies with chamber pressure, which can lead to additional instability.

'Screaming', or high-frequency instability, is ascribed to the interaction of factors such as these with the normal modes of oscillation of the gas in the combustion chamber. Only 'longitudinal' modes (with motion along the axis) are here treated, although the authors admit that transverse and rotary 'sloshing' modes should also be considered important, as more recent work has, in fact, emphasized. M. J. Lighthill

Atomic Physics

An Atomic Description of Physical Phenomena. By Prof. Gaylord P. Harnwell and Prof. William E. Stephens. (International Series in Pure and Applied Physics.) Pp. x+401. (London: McGraw-Hill Publishing Company, Ltd., 1955.) 60*s*.

THIS book exhibits the difference between the methods of teaching in American and British universities. It is based on a course of lectures given by the authors to first-year postgraduate students at the University of Pennsylvania. The standard is suitable for British undergraduates in their final year; but the book would be expensive for students here at 60*s*. The nearest equivalent published in Britain is Max Born's "Atomic Physics".

D. F. Johnston

THE CALDER REACTORS: RESEARCH AND DEVELOPMENT PROBLEMS

By L. ROTHERHAM

Director of Research and Development, U.K. Atomic Energy Authority (Industrial Group)

THE design of the reactors at the Calder Hall Atomic Power Station, opened by H.M. The Queen on October 17, sprang directly from a proposal made at the Atomic Energy Research Establishment in 1953 for a small power reactor called PIPPA to supply the electricity needs of the Establishment. This reactor was never constructed; but many of its main features have been retained in the Calder Hall reactors designed and built by the Industrial Group. No fuel other than natural uranium being available, a thermal neutron reactor with graphite or heavy-water moderation was essential. Heavy water was very expensive and not readily available in the United Kingdom. Its use would have required the core to be carried inside an exceedingly massive pressure shell in order that the necessary working temperature could be reached, and there were fears, which later experience has shown to be well founded, that there might be difficult problems in preparing fuel elements sufficiently resistant to corrosion by water at high temperature. The use of natural water-cooling for a graphite-moderated reactor is not physically impossible, but the same corrosion problems exist and it is doubtful if coolant tubes strong enough to stand the pressure can be made which will not absorb neutrons so avidly that a natural uranium pile becomes impracticable. The choice, therefore, fell on a gas-cooled graphite-moderated design. Many gases were considered from the aspects of coolant efficiency, neutron absorption, chemical stability and inertness at the working temperature and ease and cheapness of acquisition. Carbon dioxide was chosen, as it combines to a remarkable degree the desired qualities. Its nearest rival is helium, which can only be obtained from dollar sources and incurs high transport costs.

The choice of a graphite-moderated reactor cooled with carbon dioxide was supported by the belief that such a reactor could be built with a simple development programme in which all important problems could be foreseen at the start, and attacked simultaneously. Many types of reactor which have great potential advantages can only be constructed after a two-stage experimental programme has been carried through. For example, the nuclear-hydraulic mechanism which determines the manner and rate of boiling in a boiling-water reactor cannot safely be elucidated by theoretical studies alone, and the design of such a reactor for economic power must be preceded by the building and operation of an experimental reactor. This would delay the main programme by three to five years. For Calder Hall much useful information was available already from experience with BEPO and the Windscale piles, relating particularly to uranium fabrication and the manufacture and behaviour under irradiation of graphite. Unlike the water-cooled piles, the pressure of operation was determined by the economics of the circulating blowers and not by temperature, and a pressure of 7 atmospheres was chosen which led to a design for a pressure vessel only just outside previous experience. There was a further feature of great importance in the design. The use of natural uranium and the relative absence of neutron-absorbing material from the core allowed a good 'neutron economy'—that is, led to the maximum number of spare neutrons being captured in uranium-238 rather than in structural material or coolant. As a result, the 'conversion ratio' (number of plutonium atoms produced per uranium-235 atom fissioned or converted to uranium-236) is very satisfactory. Higher values can be obtained with cold heavy-water moderated piles of large size because of the very low capture cross-section of heavy water; but they are less likely to be realized with heavy-water power piles because of the presence of more extraneous material in the core and increased neutron leakage. As the Calder Hall reactors produce plutonium with by-product power, this high conversion ratio was desired; but it is just as valuable for a pure power pile because it allows better utilization of the fuel in each irradiation cycle.

The development programme comprised numerous individual jobs carried out at the Atomic Energy Research Establishment and in the laboratories of the Research and Development Branch of the Industrial Group. Some were started at Harwell before the design had been accepted for construction by Risley; but Harwell and the Industrial Group worked side by side thereafter. Only a selection from the experimental and theoretical work is described here.

Even if neutron cross-sections at all relevant neutron energies for all materials in the core were known, it would not be possible to calculate sufficiently accurately the reactivity of the fully loaded core. 'Exponential experiments' were therefore carried out at Harwell, in which the distribution of neutron flux was measured in sub-critical piles supplied with neutrons from an external source. These piles had lattice structures similar to that proposed for the main one, and from these measurements it is possible to deduce the reproduction constant of the infinite lattice, and the migration areas which determine the rate of escape of neutrons from a finite core. These quantities are needed to allow the effective reproduction constant of the actual reactor to be calculated. In principle, this type of experiment should give all the information needed. In practice, it is usually not possible to represent the actual reactor lattice arrangement exactly, because it is not known in time, nor can the effects of high temperature easily be simulated. Considerable theoretical ingenuity has to be employed in making use of these measurements. The original Harwell core design was chosen on the basis of existing knowledge to combine large power output and small core diameter while employing natural uranium. A re-evaluation was made in the Research and Development Branch at Risley, starting from a

given core size fixed by the engineers, and aiming at optimum plutonium production without necessarily insisting on the use of natural uranium (by that time enriched uranium had become available from the Capenhurst Diffusion Plant). This led to changes which appear slight, such as an increase in the uranium rod diameter from 1 to 1·15 in., but which have quite significant effects on conversion ratio and other properties. When the structure was settled in detail, the expected reactivity was re-calculated, making the fullest allowance possible for the existence of zones of different properties within the core. These exist because of the different fuel channel sizes and varied expansion gaps between graphite bricks that are provided in different parts of the reactor. An ideal theoretical treatment of this problem, in which the neutron flux distribution in each zone is properly 'matched' to that in its neighbours by suitable boundary conditions, is not possible at present. We hope that by the use of automatic computers particular cases will be solved in future. For the present, judicious averaging and adjustments have given results in tolerable agreement with measurements, and by sound judgment and some luck the pile has turned out to be capable of operating on natural uranium. There are other theoretical problems which have to be solved in designing a reactor of this sort. The effectiveness of control rods, and the flux of radiation outside the core vessel must be calculated. The latter is needed in designing the shield and instrumentation.

Apart from these studies on 'neutron engineering', a considerable amount of development work to improve the heat transfer of the fuel was carried out both at the Atomic Energy Research Establishment and in the Industrial Group laboratories. Heat transfer generally imposes a limit on the maximum operating power of a gas-cooled reactor, in that it is impossible to remove more than a certain amount of heat from fuel elements at a given temperature without the expenditure of excessive power in circulating the coolant through the reactor. It is always possible to remove this limitation by increasing the coolant pressure, although structural considerations then impose a limit. Anything which can be done to increase the heat-transfer properties of the fuel elements themselves is therefore greatly to be desired.

The first line of development, used in the Windscale reactors, was to increase the heat-transfer surface by the addition of longitudinal fins to the fuel container. It was possible, by this means, to achieve ratings (MW./tonne) some five times greater than those which would have been possible with plain cylindrical fuel elements. Further development of this type of extended surface proved difficult because of poor mixing of the gas between the fins with that towards the outer diameter of the channel. This is a difficulty inherent in the gas-cooled natural uranium reactor, since the channels must be of large diameter (that is, about 4 in.) to accommodate the flow of coolant, and the fuel must be in the form of a cylindrical rod, for reasons of neutron economy.

Experimental work at Harwell led to the development of turbulence promoters, and a significant improvement was obtained by the use of these in the Windscale reactors. More important, however, this work led to the development of the transverse finned Calder fuel element. This type of fuel element achieved a given heat transfer-rate with a smaller mass flow and a higher outlet temperature than the longitudinally finned type, and the power required to pump the coolant is also rather less; it is therefore well suited for use in a power reactor where a high outlet temperature of coolant is desirable. Experiments have shown that there is a well-defined circulation in the form of two vortices 'geared together' in the space between the fins and maintained by the flow at the fin tips. It is this systematic circulation rather than the production of random turbulence which accounts for the good heat-transfer properties of the transverse finned element.

The instrumentation of the reactor presented a number of novel problems. For example, it is essential in a high-power reactor to be able to detect fuel elements with damaged sheaths. This is done by monitoring samples of the coolant gas for fission-product activity. Each of about two thousand fuel channels has a sampling pipe which runs through the pressure vessel to a selector valve and thence to a detector, the samples being returned to the circuit by a special blower after monitoring. The samples are filtered to remove solid matter and are then exposed in a precipitation chamber where solid decay products from gaseous fission-product elements that may be present are deposited on a wire. The wire is drawn into another chamber, where it is observed by scintillation particle detectors which report its state of contamination. The counter assembly, which has to work in high-pressure carbon dioxide, was developed in the laboratory at Windscale.

The principal metallurgical problems of the Calder reactors were concerned with the fuel elements and the pressure vessel. These are always likely to be key problems in reactors of this type, since there will always be technical and economic advantages in designing as close as possible to the limit on these points. At the same time, an extremely high degree of reliability is required in both fields. It will be obvious that a major failure of the pressure vessel could be a very serious matter, especially if it occurred in a brittle fashion. Although failure of a single fuel element would not be disastrous, only an extremely low incidence of failure can be tolerated if the reactor is to operate consistently; furthermore, this degree of reliability will be required for increasing lives in the future.

Pressure Vessels

The general problems of building steel pressure vessels for reactors of the Calder type are extremely interesting scientifically. The size of the Calder vessels, the thickness of steel plate involved and the continuity of the welded construction are all features which increase the tendency of the structure to fail in a brittle manner. In addition to the problem of brittle fracture, however, the temperature-range in which creep becomes important may be entered, and this is a combination of circumstances which is quite unusual. In addition to these factors, site fabrication, the oxidation resistance of the steel, the stress relief and inspection of the completed vessel and the effects of irradiation on the steel must be taken into account.

Certain general features of the brittle fracture phenomenon have now been elucidated, and it is recognized that steels vary in their tendency to propagate or to arrest cracks. Methods of reducing the tendency to brittle failure by means of composition and/or heat treatments are available, although the difficulty of doing so increases with thickness of plate. Unfortunately, however, there is no way of applying

the available data quantitatively in a design, so that design engineers must exercise their judgment in a qualitative fashion, based on previous experience. At the same time, metallurgical features which provide a higher measure of notch ductility may reduce creep resistance; the grain size is particularly important, a fine grain being desirable for a low temperature (for the transition from brittle to ductile fracture) but disadvantageous from the creep point of view.

Up to about 375° C., creep effects can largely be neglected in the design of steel structures. However, if the pressure vessel is exposed to the hottest gases as well as irradiation, which causes internal heating, the creep range may readily be entered. In this case, the provision of adequate long-term creep data becomes a very difficult problem, since very long lives are involved and allowable strains are very small: 0·1 per cent strain in twenty years is typical. In addition, relatively little is known of the ductility that may be expected under these conditions and for such long times. In the case of the Calder reactors, only modest cooling was required to avoid creep problems, and this solution was accepted. It was then possible to select a steel with excellent notch ductility so that the maximum factor of safety from brittle fracture was provided. In future designs, however, which may be required to operate with higher gas temperatures but where at the same time cooling would be more unattractive on economic grounds, it may be necessary to deal with both creep and notch ductility simultaneously. There is scope for the development of special steels to withstand this combination of conditions, and this is being pursued with encouraging results.

The effect of irradiation on the properties of steels is not fully understood, especially when the irradiation is carried out below about 300° C. Samples have been loaded into the Calder piles both to provide a continuous check on the condition of the steel in these reactors and to provide more quantitative data for future designs.

Oxidation studies in carbon dioxide carried out on steel samples indicated that no important problem need arise in reactors of this type. Site fabrication and inspection problems, however, required considerable thought, and this is likely to be the case in subsequent reactors also.

Fuel Elements

For the fuel elements, a very considerable research and development programme was required. This programme may be divided arbitrarily into the following three phases, although it will be realized that there was actually considerable overlap in time: (*a*) feasibility studies; (*b*) specification of fuel element and of manufacturing processes; (*c*) studies of probable behaviour in the reactor.

During the feasibility period, it was necessary to show that the general style of fuel element proposed was broadly satisfactory, both from the point of view of manufacture and pile behaviour; in particular, the feasibility of the general size and shape of the element and the choice of a magnesium alloy for the finned sheath had to be demonstrated. Following the decision to proceed with the reactor, one of the most urgent problems was to develop methods for the production of the cans, which involved the bulk manufacture of a completely new magnesium alloy to more rigorous standards of cleanliness than for any previous requirement and the final fixing of the alloy after many experiments on oxidation and corrosion, weldability and deformation behaviour. For the uranium bar, processes had to be developed for casting longer bars than previously used and heat-treating them to a newly defined metallurgical condition. The fuel element manufacturing processes were, of course, completely new, and included many stages; those of greatest importance are probably welding of the end seals, decontamination of the external surface from traces of uranium and the final inspection processes needed to guarantee the high standards of reliability required.

The last category of work, however, that of studying probable behaviour in the reactor, is of greatest interest scientifically and, of course, is devoted not only to proving the first fuel elements but also to the development of better fuel elements, both for the Calder and more advanced reactors. The aim has been to try to predict the various changes that may occur in service which may influence the behaviour or life of fuel elements and to determine, with progressive accuracy, their magnitude. This work permits an estimate of the life of the first fuel elements to be made and, by indicating the probable limiting features, is expected to lead to rapid improvements in the elements for these reactors and valuable information for the design of future reactors.

Unfortunately for the analytical studies, very little information was available on irradiation damage at the outset and, up to the present time, experiments on prototype fuel elements have necessarily been limited in such respects as size, burn-up and thermal and neutron gradients; this is inevitable in the current phase of reactor development. However, theories existed concerning the mechanisms of irradiation damage in uranium, both as regards overall dimensional changes and local surface effects ('wrinkling'). These theories predicted that improved stability would be obtained from a fine and random grain structure. Evidence that this was likely to be true under Calder conditions was obtained, and suitable heat-treatment processes were defined just as the cartridge production line was being constructed. It is believed that this particular problem has been solved, and that the Calder cartridges will be adequately stable to the burn-up required. New phenomena are, of course, expected to become increasingly important as future reactors of the Calder type require higher burn-ups and temperatures; ideas on these matters are developing.

For various reasons it was desirable in the Calder reactors to make the fuel elements as long as possible and to stack them vertically, one above the other. It was appreciated that this would probably lead to progressive bowing of the elements, especially in view of the high density of uranium, and this has led to an extensive creep programme. Relatively little was known of the creep behaviour of uranium, and the present work has been complicated by a number of factors, including the complex longitudinal and radial thermal gradients in the uranium column, which had to be based on calculation rather than experiment. The calculation of bowing from basic creep data, therefore, proved difficult, particularly as the strain-rates of interest were very much lower even than those determined in high-sensitivity creep tests. Furthermore, the creep properties of different uranium specimens varied greatly, and were affected to an unusual extent, compared with other metals, by trace impurities and grain size. Although the uranium as produced at Springfields is an exceptionally pure

metal, it had not previously been necessary to relate impurities to mechanical properties, and this new requirement coincided both with development work to produce purer uranium and with the heat-treatment studies mentioned above. In addition to the tensile creep work, it was desirable to carry out rig tests, both in and out of pile. Finally, A. H. Cottrell, of Harwell, has considered the possible effects of irradiation on creep behaviour; this work, which is to be published shortly, indicated a possibly important effect which had to be taken into account. Despite these difficulties, it has been possible to give a reasonable forecast of bowing behaviour in the Calder reactors. Although this is unlikely to be an embarrassment in these reactors, the information obtained will probably lead designers away from the use of uranium as a load-carrying member in future power reactors.

Although it was necessary to study the magnesium canning alloy from many points of view, the work on mechanical properties is probably of greatest importance. In the pile, the magnesium must have adequate strength, both as a link in the load-carrying structure and also in order to retain the correct shape of the heat transfer surfaces. At the same time, there must be sufficient ductility, in the presence of welds and other stress-raising features, to withstand, without the formation of the slightest crack, the inevitable strains resulting from the temperature and irradiation effects on the cartridge, some of which have been mentioned above. This combination of properties is required under irradiation over the whole range of temperature encountered in the pile.

Magnesium, a hexagonal metal, has relatively low ductility at room temperature, whereas at the higher temperatures in the Calder reactors its strength is falling off rather rapidly. However, in view of the advantages from using magnesium, careful work was undertaken to assess these factors and to modify the properties of the material, as necessary. Many creep tests were carried out, including some under predetermined strain schedules rather than with a fixed load, since this gives more information on the unusual strain conditions in the reactor. In these tests particular attention has been given to ductility, both general and local, and to the phenomena related to the onset of crack formation. Two interesting features have been noted. One is that under appropriate conditions, small voids are formed; these have a characteristic size and concentration determined both by the material and the strain conditions, which may include irradiation. The other feature is that grain size, frequently a disadvantage with magnesium alloys, has a large effect on deformation mechanisms. The grain size of interest, of course, is that which is stable at reactor temperatures, and this increases the difficulty of control. For the first cartridges for Calder, major changes in composition were not possible; but modest adjustments to the composition of the alloy were found to be useful as a result of critical strain/grain growth experiments. Although for the future a complete theoretical survey of magnesium alloys has been carried out and several systems selected for experimental work, there is a growing feeling that the present material has a combination of properties fairly well suited to the wide and somewhat conflicting requirements of reactors of this type.

The work of the development teams, of course, was not ended with the completion of the reactor. During the start-up the physicists of the team worked on control problems and made the nuclear measurements which have confirmed the work of the past years.

The effect of varying the operating parameters was studied, the effect of fission-product poisoning determined, the control rods calibrated and their optimum disposition investigated; in general, a very clear picture of the characteristics of the reactor was obtained.

Work will continue in future years, and facilities are provided in the reactor to permit the study of the effect of irradiation under the appropriate conditions on fuel, graphite and pressure-vessel steel. Teams of the Research and Development Branch of the Industrial Group, together with their colleagues in the four industrial nuclear power companies, are working on the advancement of the technology of gas-cooled reactors. Calder presents the first step in the carefully planned development of gas-cooled nuclear power stations. The experience on the first reactor, and the improvements we now know can be made, lead us to believe that the decisions taken several years ago were the right ones.

GEOLOGY OF KILIMANJARO*

By Dr. C. DOWNIE, Dr. D. W. HUMPHRIES, W. H. WILCOCKSON and P. WILKINSON

KILIMANJARO, situated on the border between Kenya and Tanganyika, presents special claims for geological attention. In the first place, it is one of the largest volcanic mountains in the world and the highest mountain in Africa, the summit reaching 19,340 ft. above sea-level. The mountain mass is 50 miles long and 30 miles wide and contains more than 1,000 cubic miles of volcanic rock. Though only 200 miles south of the equator, because of its great height it has a permanent ice cap and exerts important local meteorological effects which are a major factor in the provision of water for the surrounding important agricultural region. In the second place, Kilimanjaro belongs to the East African Rift Valley petrographic province, the rocks of which belong to the alkaline suite which plays so prominent a part in petrogenetic theory. The association of rocks is so characteristic that apart from certain localities in East Africa, of which Mount Kenya is one, it can only be closely matched, petrographically and chemically, in the widely separated areas of the Oslo District in Norway and the Ross Archipelago in Antarctica. Detailed analysis of the geological and tectonic features of these areas, already known to be similar in certain respects, may be expected to throw new light on the origin of the rocks and on theories of petrogenesis generally.

Such considerations, together with the question as to whether Kibo, the highest summit, is likely to erupt again, and doubt concerning the effects on

* Substance of a series of papers read before Section C (Geology) on August 31 at the British Association meeting in Sheffield.

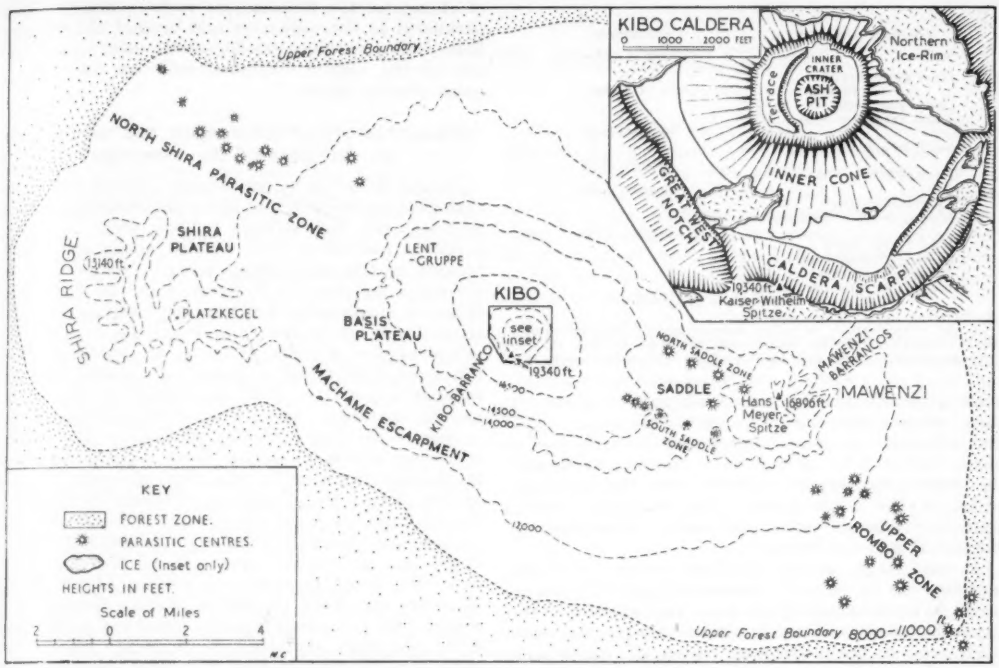


Fig. 1. Map of the Kilimanjaro area (reproduced, by permission, from the *Geological Magazine*, 1956)

water-supply of the shrinking glaciers, prompted the Geological Survey of Tanganyika to invite four members of the staff of the Geological Department of the University of Sheffield to join with three of its own geologists in making a reconnaissance survey of the mountain in 1953. The results so far obtained[1] are briefly set out here.

Composition and Structure of Kilimanjaro

The volcanic mountain rises more than 15,000 ft. from a platform of basement rocks varying from 2,500 to 4,000 ft. above sea level. Since the geological age of the mountain is not great, its innermost portions have not yet been laid bare by erosion, so that, generally, knowledge of its superficial rocks only can be obtained; the one really deep section to be seen is at the east end where two great gorges, the Mawenzi Barrancos, have been cut and expose between 4,000 and 5,000 ft. of volcanic rock. Nevertheless, it is clear that, from an early stage, activity was concentrated at three main centres corresponding to the main topographical heights, Shira, Kibo and Mawenzi, and the early activity at these centres may well have been contemporaneous. So far as can be seen, the early lavas were trachybasalts, which later gave place to phonolitic rocks.

The most degraded of the three peaks is Shira, a trachybasaltic cone which attained a height of 18,000 ft., but underwent cauldron subsidence. The resulting caldera is now represented only by the south and west walls, which form a long ridge rising to little more than 13,000 ft. After the cauldron subsidence was complete, an inner cone, the Platzkegel, was built and the volcano was invaded by a suite of radial dykes. At one point on the ring-fracture a parasitic vent erupted phonolitic lavas. After activity at this centre ceased, the eastern and northern walls were eroded and the caldera floor was flooded by lavas from Kibo.

Mawenzi, the eastern peak, has also suffered much from erosion and is now a craggy mountain, nearly 17,000 ft. high, with little resemblance to a volcano. It also is composed almost entirely of trachybasaltic rocks; but locally, in the later stages, flows of olivine basalt occurred. The rocks of the upper parts of the mountain were described by the German workers as "Brockentuffen", but, though true agglomerates do occur, a large proportion of the apparent pyroclastic rocks have proved to be flow breccias which are unusually thick in comparison with the amount of solid lava. This indicates that these lavas must have moved with a flow mechanism which may be related to the formation of 'aa' as reported from the volcanoes of Hawaii. Mawenzi was essentially a volcanic cone of which the structure has been complicated by multiple vents. The plug of dioritic rock filling the main vent is exposed in the East Barranco at 14,000 ft. The last phase of the vulcanicity of Mawenzi was the intrusion of an extensive suite of trachybasaltic and basaltic dykes, more than a thousand in number, most of which are grouped in a parallel swarm, though some of them have a radial arrangement.

At the end of the period of effusion of trachybasaltic lavas Kibo formed a cone probably about 18,000 ft. high; but activity continued here after the eruptions had ceased at the other centres. These later eruptions began with the outpouring of rhomb-porphyries followed by other phonolitic lavas by which the present complex puy-shaped cone was

Table 1

Volcanic Activity	Sediments
Solfatari	Inner Moraines
Inner Crater Series	
Erosion	? = Outer Moraines
Calder Rim Series and Parasitic Cones	
	Boulder Beds
Small-Rhomb-Porphyry	
	Boulder Beds
Phonolite	
	Boulder Beds
Rhomb-Porphyry*	
Lavaturm-type Phonolite	
	Boulder Beds
Kibo Trachybasalt Mawenzi Trachybasalt Shira Trachybasalt	
10,000 ft. of lavas unexposed	
Erosion of Pliocene surface (Dixey)	

* Lavas characterized by stout, tabular plagioclase phenocrysts, called rectangle-porphyries, occur near the base of the rhomb-porphyry series and also near the top of the Kibo trachybasalts.

built up (Table 1). The mountain gives evidence of three distinct episodes of cauldron subsidence. The first affected the main rhomb-porphyry cone, but is much obscured by later flows. The second formed the present topographic caldera, and the third the crater of the Inner Cone. In the Inner Crater, solfataric activity with extensive deposition of sulphur is still continuing[2].

A late stage in the volcanic history was the development of a large number of parasitic cones, some forty of which have been mapped above the forest belt alone. They are distributed along west-north-west to east-south-east and north–south lines across the mountain and are composed of pyroclastic rocks and basic and ultrabasic lavas.

Petrogenesis

The trachybasalts are striking rocks containing abundant thin tabular phenocrysts of plagioclase in a matrix of plagioclase with some potash felspar, augite and iron ore. They are present in great volume and, so far as can be seen, make up the greater part of the mountain. On the other hand, the phonolitic lavas have a much smaller bulk and do not exceed 1 per cent of the total extrusives. The rhomb-porphyries, the most abundant of the phonolitic types, contain large phenocrysts of anorthoclase, usually with olivine in a fine-grained matrix generally of alkali felspar, augite and iron ore. They have much in common with similar rocks from Oslo, Mount Kenya and the Ross Archipelago. In the more alkaline lavas poured out late in the history of Kibo there is abundant nepheline, often as large phenocrysts. The basic and ultrabasic rocks, found principally interstratified with the trachybasalts of Shira and in the parasitic cones, are olivine basalts and ankaramites rich in augite and olivine. These lavas are of distinctly alkaline character, and, in some cases, develop abundant large nepheline phenocrysts and so may be called ankaratrites.

Consideration of the succession, petrographic characters and the chemical variations of this rock series indicates that we are here dealing with a consanguineous suite, with a parental magma near to the trachybasalts. The ultrabasic rocks appear to have formed by the accumulation of early augite and hornblende. The later phonolitic lavas show an enrichment of alkalis, suggesting a course of differentiation similar to the line of descent described from other alkaline volcanic provinces. The general trend of change in the Kilimanjaro rocks is fairly closely paralleled in the region in and around the Gregory Rift Valley, where trachybasalts are widespread among the earlier eruptions and are followed by more alkaline types.

Glacial History of Kilimanjaro and its Bearing on the Date of the Vulcanicity

During intervals in the effusion of lava it is clear that glaciers extended far down the mountain slopes. Boulder beds with striated pebbles occur at several localities associated with bedded sands and valley erosion in the pre-existing lavas. No evidence of glaciation appears to be present in the Shira and Mawenzi successions, and the last activity of these centres appears to have pre-dated the ice age. The younger lavas of Kibo, however, are separated from the trachybasalts by a period of erosion, and the succeeding activity, which is confined to this centre and the parasitic cones, was interrupted on several occasions by major glacial episodes. The glacial sediments deposited during these periods are found at definite horizons in the lava sequence on and around Kibo, and these are indicated in Table 1. Succeeding all activity, except for solfataric activity and perhaps the outpouring of the Inner Crater lavas, there was a further extension of the ice which deposited great moraines as low as 11,000 ft. on Mawenzi and Shira as well as Kibo. Nilsson[3] suggested that these belong to the Gamblian period, and it is therefore tempting to correlate the earlier extensions of glaciers with the three earlier Pluvial periods of East Africa, and the more recent moraines with the succeeding Makalian and Nakuran episodes. Thus the main activity of the mountain is pre-Pleistocene and, if Dixey[4] is correct in his interpretation of the Pangani River system, of Pliocene age. During the Pleistocene period only Kibo was intermittently active; but it is uncertain if any activity, except that of the solfatari, persisted into the post-Glacial period.

Present Glaciers of Kilimanjaro

The present glaciers of Kibo are but the ragged fringe of the ice cap which formerly covered the whole summit of the mountain, the centre having largely disintegrated and ablated. There is no ice in the Inner Crater or in the Ash Pit. Within the Caldera Wall there are isolated, stagnant ice masses which are decaying rapidly. The major glaciers occur on the southern and western flanks of Kibo, the Penck Glacier reaching to below 16,000 ft. These glaciers commence just below the crest of the Caldera Wall and are thus cut off from any potential gathering ground (or 'névé-field') on the summit of the mountain. The glaciers of the northern slopes are more limited in extent, and although commencing within the outer crater wall are also without névé-fields. Thus the glaciers of Kilimanjaro are almost stagnant, and their recession is rapid. It seems likely, therefore, that within a few decades the ice will have entirely disappeared.

From such a reconnaissance survey our knowledge of the mountain must still be incomplete. It is hoped to fill in some of the gaps during a second expedition in 1957.

[1] *Geol. Mag.*, **93**, 218 (1956).
[2] Unpublished reports of the Geological Survey of Tanganyika.
[3] *Geograf. Ann.*, **13**, 276 (1931).
[4] *Quart. J. Geol. Soc.*, **102**, 351 (1946).

GLASS: RECENT RESEARCH AND DEVELOPMENTS

THE systematic study of glass and the subject of glass technology is a field with which the University of Sheffield is particularly associated, Sheffield being the only University in the United Kingdom which has a Department of Glass Technology, and, in fact, this was the first such Department in the world.

The existence of this Department and its growth is largely due to the work and vision of Prof. W. E. S. Turner, who first organized the Department in 1915 and became the first professor of glass technology in 1920. It was very fitting, therefore, that Prof. Turner should have been present to give an introductory talk to the meeting of Section B (Chemistry) of the British Association on September 4 at Sheffield which was devoted to glass. In his talk, Prof. Turner dealt with the history and development of the subject since 1910, the year in which the British Association last met in Sheffield. He referred to the parts which chemistry, physics and engineering have played, and continue to play, in the extension of understanding and practice in the industry, themes which were developed by the subsequent speakers.

Prof. R. W. Douglas, the present occupant of the chair of glass technology in the University of Sheffield, spoke on the nature of glass. After stressing the importance of the viscosity of glass and the manner in which it varies with temperature in glass manufacturing processes, he said that this relation of viscosity with temperature is of fundamental importance in any discussion of the chemistry and physics of glass. The high viscosity is associated with the nature of the forces between the atoms; the directed bonds between silicon and oxygen being particularly important.

Silica melts at 1,713° C.; but the liquid so formed flows with great difficulty because of these strong directed forces, and it is easy to cool the liquid through its freezing point without its solidifying. It is this mechanism which makes the formation of glass possible, and in this sense glasses are supercooled liquids.

On cooling further, a second stage of thermodynamic instability is reached. The distribution function of a liquid has a particular value for each temperature; but the difficulty of the atoms moving in respect to one another increases rapidly as the temperature falls, until the time taken for the distribution function to reach the value appropriate to the lower temperature becomes long compared with the time taken to make an experimental measurement. The properties of glass then appear to vary with time towards equilibrium values corresponding to the temperature of the experiment. This behaviour is observed when the temperature falls below that at which glass has a viscosity of about 10^{13} poises.

Eventually, after cooling roughly another hundred degrees, the rate of approach to equilibrium configuration becomes so slow that the distribution function is fixed. At room temperature glass is therefore a very special type of solid which has the macroscopic mechanical properties of a solid but in which the atoms are arranged with the disorder of those of a liquid and in which thermal motion of translation has ceased.

The function of other oxides, added to silica to produce glasses which have properties required for ease of fabrication, were mentioned briefly.

This theme was taken up by Mr. W. J. R. Merren, of Pilkington Brothers, Ltd., who dealt with new glasses. This title included many special kinds of glass which had been prepared to meet the demands of scientific development, the needs of research, and of new developments in various industries.

New optical glasses which have very high refractive indices were mentioned; these contain considerable amounts of the rare-earth element, lanthanum. Another development in optical glasses has been the production of glass of extremely high transparency. This involves the use of very pure materials and the melting of the glass batch in platinum vessels on a commercial scale.

Other glasses have been developed which absorb infra-red radiation, and are very useful, for example, in projectors to prevent overheating of the slides. Glasses are also required which transmit infra-red radiation. In preparing these glasses it is important to reduce, so far as possible, the very small amount of water which ordinary glasses can contain, for this small amount is enough to cause very marked absorption. It seems that for work beyond 5μ, glasses based on silica will not be useful; in this region selenium and sulphide glasses can be used, arsenic sulphide glass transmitting out to 15μ.

The developments in atomic energy have also made demands on the glass technologist. Radiation-absorbing glasses have been sought for one type of protective window, and a lead glass which contains as much as 80 per cent lead oxide has been made for this window. A window 3 ft. × 2 ft. × 2 ft. (the great thickness is necessary to get sufficient absorbing power) will weigh about 4,000 lb. A similar glass, when especially pure and transparent, has found application as a γ-ray detector by using the Čerenkov radiation.

Certain glasses have the property of changing under the action of harmful radiation, either developing a colour or an ability to fluoresce which they did not possess before, and so can be used to measure the 'dose' of radiation to which they have been exposed. Glasses such as these are quite different from the normal soda–lime–silica glass. Glasses for absorbing X-rays, for example, may contain large quantities of elements such as tantalum, boron, phosphorus and germanium, while the dosimeter glasses are potassium, barium, aluminium phosphates with as much as 7 per cent silver in them.

Dr. J. H. Partridge, of the General Electric Co., Ltd., continued Mr. Merren's theme, dealing with the demands which the lamp and electronic industry has made for new glasses. Here again, constituents which had not been thought of as useful in glass-making thirty years ago are being used, or constituents such as soda and other alkaline oxides which were considered essential in earlier times are omitted. For example, the inner tube of the mercury lamp which is familiar in street lighting installations is made of a glass which contains no alkali. At 700° C. an evacuated tube of this glass about 30 mm. in diameter and 1 mm. wall thickness will become distorted only very slowly.

Another glass, used for making the sodium discharge lamp, is remarkable in that it contains no silica. This is in order that it shall withstand the attack of the sodium vapour. Other special glasses have had to be developed in order that suitable wires can be sealed through glass to secure and make contact with the electrodes in thermionic devices; such glasses must have a very high electric resistance. Dr. Partridge's paper was illustrated by an excellent colour film of glass-making operations; this film emphasized the changes in normal procedure entailed in making articles from some of these special glasses.

A paper different from the others, in that it dealt with a new industry which has grown out of the glass industry itself, was presented by Dr. A. De Dani, of Fibre Glass, Ltd. Glass fibres may be drawn as single continuous fibres or by the glass wool process. This process consists in subjecting a stream of glass issuing from a platinum orifice to an intense blast of superheated steam. The stream of glass is thus shattered, resulting in a multitude of very fine fibres of glass. It was thought at one time that the steam shattered the glass into droplets which were then drawn into fibres, but calculations showed that this explanation was not very probable. The process has therefore been investigated using high-speed ciné photography.

Some of the films taken in the experiments were shown to the meeting. The audience was thus able to see an example of industrial research in a new development of the glass industry, thereby completing the review of the many-sided aspects of glass technology—a subject in which physics and chemistry must be applied for a fundamental understanding of the material, in which physics, chemistry, engineering and mathematics are applied in the industrial development, and an industry which, although several thousand years old, is now, with few exceptions, such as high-quality table-ware and decorative pieces and the production in small quantities of special glasses, a fully mechanized industry.

SEVENTH INTERNATIONAL ASTRONAUTICAL CONGRESS

THE Seventh International Astronautical Congress was held in Rome this year during September 17–22, and was attended by more than four hundred delegates from many various countries and of equally varied interests. There is, of course, practically no scientific subject which is not involved in astronautics one way or another, and which does not stand to profit from its findings. The proceedings took place in the magnificent Congress Hall of the Espozisione Universale di Roma, and during the two and a half days of technical sessions more than forty papers were presented. An unusual feature—at least for a scientific meeting—was the use of a simultaneous translation service in Italian, French, German and English. Despite the valiant efforts of the Italian linguists providing this service, it would no doubt have been improved had the translators been natives of the country into whose language they translated, and had they had a knowledge of scientific terminology. These stern requirements would seem necessary to ensure the complete success of such a service.

With so many papers to be presented, only a quarter of an hour was allotted to each speaker, and there was practically no time for formal discussion. This made the task of digesting the contents of many of the lectures difficult, particularly as many of them were not available in printed form. Special interest was aroused by the contributions of the delegation from the United States, who, numbering among them the first professional 'astronautical engineers', introduced an atmosphere of reality unusual in conferences on this subject. With regard to the speculations concerning the relative progress of the American and Soviet attempts to set up an artificial Earth satellite, it is not inappropriate to remark that the only Soviet delegate, Prof. L. I. Sedov, of the U.S.S.R. Academy of Sciences, disclaimed any knowledge of his countrymen's progress in this venture and declined to make any statement on the subject.

The American artificial satellite, or to give it its code name, 'Project Vanguard', formed the subject of many papers. It is to be a three-stage rocket, appearing, however, to be composed of only two stages, because the last stage is carried inside the second. The initial stage is 44 ft. long and 45 in. in diameter, and is powered by a liquid oxygen rocket with kerosene as a fuel, and pressurized by helium; it is intended to carry the projectile to a height of 36 miles, and to achieve an all-burnt velocity of 5,500 ft./sec. The casing of the initial stage, after being jettisoned, is expected to land at a distance of 75 miles from the launching station. The second stage is 32 ft. long, and employs a bifuel rocket unit with nitric acid and hydrazine hydrate as propellants, and also pressurized by helium. It is expected to increase its speed to 13,400 ft./sec. at all-burnt, when its height would be 140 miles. Besides enclosing the final stage, it contains the control and guidance equipment, which is to be brought into action during a period of coasting flight after the operation of the second-stage rocket, to effect the critical final adjustments to the course of the projectile. The final stage of the rocket is then spin-stabilized, and launched from within the nose of the second. It consists of a solid-fuel rocket mounted on a magnesium alloy sphere, 20 in. in diameter, which is the Earth satellite itself. The final velocity would have to be about 26,000 ft./sec. and it is anticipated that the perigee of the satellite's orbit would be about three hundred miles from the surface of the Earth. When the casing of the solid rocket is at last jettisoned, about ten minutes will have elapsed since take-off, and the satellite will have travelled some fifteen hundred miles from the launching point.

The projectile is finless, and control on the first two stages is to be obtained by deflecting the rocket venturi on gimbals. A considerable degree of accuracy in both final speed and direction of motion is required if the orbit is to be successfully established. As an example, if there is no error in speed and if the perigee is not to be less than two hundred miles above the Earth, nor the apogee more distant than eight hundred miles, an angular error of about 3° in

the direction of motion is all that can be tolerated. On the other hand, if there is no angular error, and the orbit is to be within the same limits, the velocity error must be no more than ± 450 ft./sec. No official commitment on expected accuracy is forthcoming, though it was suggested in discussion that as many as fifty satellites might have to be launched to give a reasonable likelihood that one might be placed in a satisfactory orbit. Precisely what would form a 'satisfactory' orbit is, in any event, difficult to define. The magnitude of the air density—and so of the drag—at such extreme altitudes is the chief factor governing the useful life-time of the vehicle, but is also one of the unknown properties which it is hoped that observation of the satellite may enable to be evaluated. Tentative estimates put the mean loss in apogee and perigee at (initially) about 250 ft. and 200 ft. per day, respectively. Because of the Earth's oblateness, the variation in the radius of the apogee and perigee is in fact oscillatory, with a period of forty days and an amplitude of about two miles.

It is hoped that observation of the track of the satellite vehicles may also supply data leading to determinations of the variation of gravitational acceleration, and of the shape of the Earth. In addition, it is hoped to be able to interlock the geodetic networks of the continents more closely than has been possible before. During the initial circuits in the orbit, the satellite can be located by the radio signals it sends out; but as the batteries have only a limited life, later observation will depend on visual and photographic records, when the satellite is visible before dawn or after sunset. In this 'Operation Moonwatch', the help of amateur astronomers all over the world is being enlisted, through the International Astronautical Federation. The track of the satellites takes them eastwards as far south as 45° latitude on the Greenwich meridian, and north to the same latitude at a longitude of 180° (so that they will not be visible in Britain). Some other data are to be telemetered from the satellites, though it seems that there is little room for the installation of many instruments. The weight of the satellite is only 21½ lb. (The complete take-off weight of the three stages is 22,600 lb., implying a mass ratio of more than a thousand.) The nature of the observations to be made was not announced, though the possibilities are without limit. High on the list of priorities is the counting of impacts by meteors. This and many other experimental techniques which might be involved are being practised already, and several of the papers presented at the Congress dealt with them.

One of the greatest of the potential hazards to man in space flight is the effect of heavy primary cosmic radiation. More than twenty-five stratosphere balloon flights conducted by the United States Air Force have carried biological specimens to altitudes above 30 km. in geomagnetic latitudes above 55°. Although no somatic health hazard has been observed over periods of about twenty-four hours—the longest period of exposure obtained—the repeated observation of streaks of grey hair on black mice, 200μ in width, has suggested that a so far unidentified mechanism causes wider radial spread of radiation effects (by some 20 times) than has been predicted before. In another paper, details were reported of personal experiences during half-minute periods in a zero-gravity condition. (These were experiments conducted in an aircraft.) The majority of the subjects tested reported as feeling "very comfortable".

Looking still further ahead, another paper discussed the time dilation effect of relativity theory, and its effect on humans travelling in a vehicle moving at speeds near that of light. The general conclusion seemed to be that man's life-time would be effectively increased to such an extent that he can survive outward journeys which in terms of light-years of distance far exceed his normal life-time.

T. NONWEILER

OBITUARIES

Prof. J. B. Leathes, F.R.S.

WITH the death, at Montreux on September 14 at the age of ninety-two, of Prof. John Beresford Leathes, physiology lost another of its dwindling links with the past century. Born on November 5, 1864, the son of a clergyman, and educated at Winchester and New College, Oxford, he also was intended for the Church; but a natural bent for science drew him to the study of medicine, and he qualified M.B. in 1893, and F.R.C.S. a year later, from Guy's Hospital, London.

A talent for chemistry, the teaching of which was a strong feature at Guy's, decided Leathes to follow the applications of chemical knowledge to the elucidation of physiological problems, in pursuit of which plan he went to work for two years with Drechsel at Berne, and then under Schmiedeberg in Strasbourg. On his return, like Sherrington before him, he was appointed to the lectureship in physiology at St. Thomas's Hospital, where he stayed for some ten years, during the last eight of which he also held a part-time appointment at the Lister Institute, which was one of the main foci of development for the rapidly evolving subject of biochemistry. He thus became one of that small and devoted band which included C. J. Martin, Harden and Young, Cathcart, Dakin and Raper, who did so much to forward the interests of that subject in its formative years. It was in that stimulating environment that his interest in metabolic problems was aroused, and where his book, "Problems in Animal Metabolism", was produced. His first published papers dealt with body fluids, proteolytic enzymes, protein metabolism, and the fat content of various muscles. Most of his subsequent work had to do with fat metabolism, and in much of this he had the collaboration of H. S. Raper; their joint monograph on "The Fats" (1910 and 1925) is still a standard work.

In 1909 he became professor of pathological chemistry at Toronto, where he was shortly joined by Raper. During these years he was elected to the fellowship of the Royal Society (1911). In 1915 he went as professor of physiology to Sheffield, in succession to J. S. Macdonald, who had moved to Liverpool, and he remained there until his retirement in 1933.

Leathes took a keen and practical interest in medical and dental education, and by reason of his work on the General Medical Council, and as dean for nine years of the Sheffield Medical School, he not only influenced his own University, but also played an important part in shaping the medical curriculum of his time. It is no more than fair to say that he, and the late Sir Arthur Hall, together were largely responsible for making the Sheffield Medical School the outstanding success it became. Their aim was to unify the medical curriculum; and they did this by weakening the barriers between the pre-clinical and clinical courses of study by extending physiology and biochemistry, with appropriate laboratories, into the ward teaching of clinical medicine—a development which has since been applied in other schools. The results of the experiment were encouraging, as also were those of an innovation which Leathes introduced into the B.Sc. course, and which consisted in making the candidates spend a further year after the final examination working up some special field, on which they produced a thesis, which had to be approved before the degree was granted. The average standard of these theses was surprisingly good, and the subject, in some instances, provided the new graduate with a field into which he could enter with some confidence for further study.

Leathes was elected to the Physiological Society in 1895, and in 1952 was accorded the distinction of honorary membership. He served for three periods on its committee, and for ten years as an editor of the *Journal of Physiology*. This latter service, often now forgotten, was perhaps his best contribution to British physiology, for he took infinite and unsparing pains in helping authors, young and old, who lacked the ability to express themselves clearly. As he was in Toronto when the Biochemical Society was formed in 1911, he happened not to have been an original member, but he joined it in 1913.

In 1921 he was elected a fellow of the Royal College of Physicians, and gave the Croonian Lecture in 1923; it dealt with fat metabolism in various aspects, and in its relation to cellular structure and functions. He also gave the Harveian Oration in 1930, on "The Birth of Chemical Biology". Other honours included the D.Sc. Sheffield in 1933, and Manchester 1936, and the honorary fellowship of New College, Oxford.

Leathes was essentially a modest and scholarly man, of kindly and phlegmatic disposition, one of the few physiologists with a classical education, and a good linguist; he began the study of Russian at the age of eighty. Tall and wiry, he was, even at that age, good for a brisk walk of ten miles or more. Among other accomplishments, he was a pastellist of discernment, despite his high degree of myopia, or perhaps even on account of it, as he was unaware of much landscape detail which tends to distract the amateur. After his retirement he moved to Wantage, and worked in the Physiological Laboratory at Oxford, with John Mellanby. Their published work, which was interrupted by the Second World War, dealt with thrombokinase, and with the action of lecithin upon it. He then moved successively to Lyme Regis, London, Southbourne, and finally to Switzerland, near the scene of some of his happier early years.

Leathes spent his life largely in helping others by patient and unselfish acceptance of responsibilities which brought no ponderable reward—service on the Council of the Royal Society, 1924–26, on the Medical Research Council, 1928–31, the General Medical Council, 1919–38, and on its Education Committee, of which he was chairman in 1931. But he will long be remembered with affection by many friends and pupils.

C. Lovatt Evans

Dr. A. E. J. Vickers

Dr. A. E. J. Vickers, who died suddenly on September 8 at the age of fifty-eight, was director of research at the Thermal Syndicate, Ltd., Wallsend, Northumberland, a position he had held since November 1947; he was elected to the Board of Directors in April 1953. His early academic education began with training in 1915 in Sheffield for the teaching profession; but, probably influenced by war work in a munitions factory, he decided to make chemistry his future profession and, following study in Stoke and London, took an external London B.Sc. in chemistry in 1922.

He then joined the late Dr. J. W. Mellor, of the British Refractories Research Association (now the British Ceramic Research Association), Stoke-on-Trent, where he developed an interest in mineralogy, and in 1927 he took the post of chief chemist to Buxton Lime Firms Co., Ltd. (now the Lime Division of Imperial Chemical Industries, Ltd.). Two years later Dr. Vickers moved to the Billingham works of Imperial Chemical Industries, Ltd., and continued investigations in the problems of refractories and in mineralogy, gaining his Ph.D. in 1935 with a thesis on the colloidal properties of clay. During the latter part of his stay at Billingham he was in charge of research on ceramics, mineralogy and physical methods, including a variety of applications of spectroscopy and microscopy, and when he moved in 1947 to the Thermal Syndicate, Ltd., his work continued to be largely in the field of ceramics, but at higher temperatures than heretofore.

Dr. Vickers was keenly interested in the work of scientific and technical societies, including the Royal Institute of Chemistry, the Society of Glass Technology and the Society of Chemical Industry, and he was a founder member of the Institute of Ceramics. He was also very much concerned with higher education, being a member of the council of St. John's College in the University of Durham. Apart from his professional work, Dr. Vickers was a keen photographer, gardener and musician, and he was an active member of the Anglican Church. He is survived by his wife and by a son and a daughter, training respectively for the medical and dental professions.

Prof. B. M. Duggar

Benjamin Minge Duggar, botanist, mycologist, plant physiologist, plant pathologist and microbiologist, who died at New Haven, Connecticut, in mid-September, a fortnight after his eighty-fourth birthday, had a long and varied career. After holding posts in his native state of Alabama and elsewhere, Duggar became professor of botany in the University of Missouri in 1902. Afterwards he was professor of plant physiology first at Cornell (1907–12) and then in the University of Washington (1912–27), from where he moved to the University of Wisconsin as professor of plant physiology, plant pathology and economic botany (1927–43). Finally, in 1944, he became consultant on mycological research and production to the Lederle Laboratories Division of the American Cyanamid Co.

Although during recent years Duggar became widely known for the part he played in the discovery and development of the antibiotic aureomycin, his name is not associated with any one particular topic. Duggar's distinction lies rather in the breadth and vigour of his interests and his lively appreciation of the novel. Throughout his working life he was always to be found actively engaged in the front line of botanical advance and he made notable contributions in many fields.

After an undergraduate period in Alabama and Missouri, Duggar visited universities in Germany (where he was presumably influenced by the 'new botany'), France and Italy, and some of his early publications related to cytological and anatomical studies on pollen development in *Bignonia* and members of the Araceae. Then he turned to plant physiology, on which he wrote later a text-book ("Plant Physiology, with Special Reference to Plant Production", 1911). During the nineteen-twenties, virus diseases of plants claimed his attention (when the results of his very pertinent studies led him to inspired speculation on the nature of the infective agent) and in 1936 he edited for McGraw-Hill the two-volume "Biological Effects of Radiation".

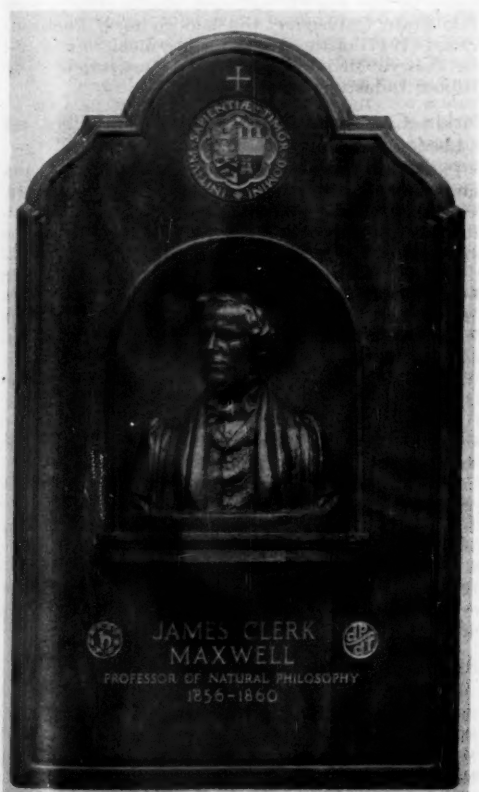
Duggar's first publication (1892) was on teleutospore germination of a rust and he maintained an interest in fungi throughout his life. Possibly, it is by his contributions to mycology and mycological plant pathology that he will be best remembered. While on the staff at Cornell he worked on diseases of fruit and vegetables and in 1909 published "Fungous Diseases of Plants", an important work which was a standard text-book for the succeeding decade and which is still remarkable for its blend of the scientific and the practical and for its modern approach. On the academic side, Duggar made contributions to an understanding of spore germination, and his physiological studies on fungi may be considered to have culminated in a well-known series of papers published in the *Annals of the Missouri Botanical Garden* (1916–19).

G. C. AINSWORTH

NEWS and VIEWS

James Clerk Maxwell: Memorial at Aberdeen

A MEMORIAL panel to James Clerk Maxwell, by C. d'O. Pilkington Jackson, was unveiled in the Mitchell Hall, Marischal College, Aberdeen, by Sir George Thomson, master of Corpus Christi College, Cambridge, on October 15. The central feature is the bronze portrait bust showing Clerk Maxwell as a young man, under thirty, when he was professor of natural philosophy in the University of Aberdeen during 1856–60. The two devices flanking the inscription are the sign for Saturn, enclosed by a laurel wreath, which refers to the paper on the "Stability of Saturn's Rings" for which Clerk Maxwell was awarded the Adams Prize at Cambridge in 1857, and the thermodynamics formula $dp/dt = JCM$, which he used as a pun on his name.



Clerk Maxwell was appointed professor of natural philosophy at Marischal College, Aberdeen, at the age of twenty-five. When the fusion of Marischal College and King's College took place in 1860, under the Universities (Scotland) Act, 1858, the two chairs of natural philosophy in Marischal and in King's were combined, like other duplicated chairs, and Prof. David Thomson of King's, being the senior, occupied the single chair, and Clerk Maxwell, not yet thirty, was retired on a pension for life. In the summer of 1860 he was appointed professor of natural philosophy in King's College, London, where he remained until 1865, when he retired to an estate which he had inherited from his father at Glenlair, in Galloway, to prepare his "Treatise on Heat" (1870) and "Electricity and Magnetism" (1873). In 1871 he was appointed to the new chair of experimental physics at Cambridge, where he designed and superintended the erection of the Cavendish Laboratory.

Agricultural Botany in Reading: Prof. A. H. Bunting

DR. A. H. BUNTING has been appointed professor of agricultural botany in the University of Reading, as from October 15, in succession to Prof. D. W. Goodall (*Nature*, 173, 894; 1954), who has been appointed director of the new Tobacco Research Institute of the Australian Commonwealth Scientific and Industrial Research Organization established in North Queensland. Prof. Bunting, who is thirty-nine, was born in South Africa, and graduated at the University of the Witwatersrand in 1937. He then proceeded as a Rhodes Scholar to Oxford, where work on the respiratory enzyme systems of barley

led to the degree of D.Phil. The war years were spent at Rothamsted Experimental Station, where his principal concern was with sewage sludge as a soil amendment. After a short period of work for the Medical Research Council, he proceeded to Tanganyika, where he organized scientific research in connexion with the ill-fated groundnut scheme of the Overseas Food Corporation. When the scheme was wound up, Prof. Bunting moved to the Sudan, where he took responsibility for setting up a new research station at Tozi, with the view of developing field crops in that area. Prof. Bunting's wide experience in large-scale field experimentation, and in applied plant physiology and ecology, should stand him in good stead in his new post at Reading. It should also ensure the continued broadening of his Department's interests which has been apparent in recent years. There is little doubt that tropical crops and conditions will occupy a prominent place in the teaching programme under his leadership, and one may expect the Department to continue as a valuable nursery for workers in agricultural research overseas.

The Kalinga Prize : Prof. George Gamow

The Kalinga Prize for the popularization of science, offered annually by the United Nations Educational, Scientific and Cultural Organization, has been awarded for 1956 to Prof. George Gamow, of the University of Colorado at Boulder. The Kalinga Prize, presented by Mr. B. Patnaik, a director of a foundation for the economic, social and cultural progress of the Indian State of Orissa, is valued at £1,000. Prof. George Gamow was born on March 4, 1904, at Odessa, and became an American citizen in 1939. He studied physics at the University of Leningrad and later was associated with the Institute of Theoretical Physics of the University of Copenhagen, the University of Cambridge and the Institut Pierre Curie in Paris. He also served as a professor at the University of Leningrad. After having taught physics during 1934–56 at the George Washington University at Washington, D.C., Prof. Gamow has just been appointed professor of physics at the University of Colorado at Boulder. Prof. Gamow is serving or has served as scientific adviser to a number of major organizations, including the Bureau of Ordnance, Department of the Navy; the Applied Physics Laboratory and the Operational Research Office of Johns Hopkins University; the Los Alamos Scientific Laboratory and the Radiation Laboratory of the University of California; the Air Force Scientific Advisory Board; and Convair, San Diego, Cal. He is well known for his scientific research, which has led to more than a hundred publications in such fields as the theory of radioactive decay and a model of an atomic nucleus, relativistic cosmology and the origin of chemical elements, and the theory of protein synthesis. Prof. Gamow, however, has not devoted his scientific career solely to research and teaching. He has also become well known as the author of some ten books and a large number of articles in the field of science popularization. Although they often treat such subjects as the theory of relativity or the quantum theory, his works combine an accurate presentation of scientific facts with an easy, good-humoured style.

Mellon Institute of Industrial Research, Pittsburgh : Dr. P. J. Flory

Since the retirement earlier this year of Dr. E. R. Weidlein as president of the Mellon Institute of Industrial Research, Pittsburgh (see *Nature*, April 21, p. 733), a new post has been established, that of executive director of research, and Dr. Paul J. Flory, professor of chemistry and acting chairman of the Department of Chemistry, Cornell University, has been appointed the first holder. The post carries the responsibility of guiding the whole field of investigation in the Institute, and for this Dr. Flory is very well suited, his career to date being divided almost exactly between academic and industrial research. After graduating from Manchester (Ind.) College, followed by postgraduate work in physical chemistry at the Ohio State University, Dr. Flory spent four years (1934–38) in research on synthetic fibres, synthetic rubbers and other polymeric substances at the duPont Experimental Station, Wilmington, Del. For the next two years he was engaged in teaching and research in the Basic Science Laboratory of the University of Cincinnati, and then, during 1940–43, was a research chemist with the Standard Oil Development Co., Elizabeth, N.J. Following this, he was head of fundamental research for the Goodyear Tire and Rubber Co., Akron, Ohio, and then in 1948 he went to Cornell University to direct graduate research in polymer chemistry. Dr. Flory's book, "Principles of Polymer Chemistry" (1953), is an authoritative work in this field. Besides his work on high polymers, however, he has carried out investigations in photochemistry, chemical reaction kinetics, thermodynamics and statistical mechanics. Dr. Flory is a member of the National Academy of Sciences and holder of the Joseph Sullivant Medal (1954) of the Ohio State University, the Leo Hendrik Baekeland Award (1947) of the American Chemical Society, and the Colwyn Medal (1954) of the Institution of the Rubber Industry (Great Britain).

Perkin Centenary Celebrations in Bradford and Leeds

The West Riding Section of the Society of Dyers and Colourists will be celebrating during October 31–November 3 the centenary this year of W. H. Perkin's discovery of the dyestuff mauveine. The celebrations will commence with two lectures: the first will be given on October 31 at 7.30 p.m. by Prof. John Read in the Hotel Metropole, Leeds, his subject being "The Life and Work of Perkin"; and on the following day, also at 7.30 p.m., Dr. C. M. Whittaker will give a lecture in the Victoria Hotel, Bradford, on "Early Stages in the Renaissance of the British Dyemaking Industry: Tales from Turnbridge, Huddersfield, 1899–1920". During November 1–3 an exhibition will be held in the Technical College, Great Horton Road, Bradford, which will illustrate the developments in dyestuffs and closely related products from the time of Perkin's discovery of mauveine to the present day and also the modern uses of dyestuffs. On November 2 the West Riding Section will hold a dinner and dance in the Victoria Hotel, Bradford. Further information on all these events can be obtained from the Society of Dyers and Colourists, 19 Piccadilly, Bradford 1.

Royal Society Antarctic Expedition

The Royal Society announces that the War Office has agreed to the appointment of Colonel Robin Smart as leader of the main party of the Royal Society International Geophysical Year Antarctic Expedition until January 1958. The main party of about twenty will leave London Docks on

November 15 in the *Magga Dan*, which is being shared with the Trans-Antarctic Expedition, and will arrive at Royal Society Base, Halley Bay, at the end of December 1936. They will relieve the advance party of ten men who sailed in the M.V. *Tottan* from Southampton on November 22, 1955, under the leadership of Surgeon Lieutenant-Commander David Dalgliesh. The main party will install the scientific equipment and erect huts so that the station is fully operating at the commencement of the International Geophysical Year on July 1, 1957. Colonel Smart will return to the United Kingdom at the beginning of January 1958; but the main party will remain at Halley Bay until the end of the International Geophysical Year on December 31, 1958. Colonel Smart, who is at present deputy director of Army health, Western Command, Chester, is forty-two years old. He graduated in medicine in the University of Aberdeen in 1936 and was commissioned into the Royal Army Medical Corps in the same year During 1948–49 Colonel Smart was a member of a War Office team working in the Arctic region of Canada and he returned to Northern Canada and Alaska in 1950.

An Optical Astronomy Observatory for the University of Michigan

A GRANT of 545,000 dollars has been made to the University of Michigan by the National Science Foundation, Washington, D.C., for the support of studies leading to the establishment of an optical astronomy observatory. The studies are under the direction of Dr. Robert R. McMath, director of the McMath–Hulbert Observatory, and are a continuation of work undertaken last year by the University with the aid of previous grants totalling 300,000 dollars from the Foundation. The most recent grant to the University includes 30,000 dollars for a study leading to the erection of a solar telescope. The establishment of an optical astronomy observatory will include initially a 36-in. and an 80-in. telescope, and work so far has consisted of a search for a suitable site, the design and erection of equipment to test the sites, and work on the 36-in. telescope. The optics for this telescope are nearing completion at Yerkes Observatory. The test equipment consists of a 'seeing' tower which is erected on potential sites for the purpose of gathering data that will help guide the astronomers in selecting a spot where an observatory can operate with maximum efficiency. The tower is a triple-shelled steel structure, 60 ft. in height, equipped with a telescope that continually measures the turbulence in the atmosphere by gauging the size of the image of the star Polaris. This information, along with wind and temperature data, is transmitted to recording instruments situated at the base of the tower. The tower will make these automatic recordings over a period of more than eighteen months. The search for a site has now been reduced to approximately five sites, all of which are situated in the south-western United States because climatic and atmospheric conditions there are favourable and because it is one of the few remaining areas in the United States where an observatory can be erected a sufficient distance from the light and dust generated by cities. Four sites at present under study are Kitt Peak (6,800 ft.) in southern Arizona, the Sierra Ancha region (7,500 ft.) in central Arizona, Chevelon Butte (6,900 ft.) in northern Arizona, and the Hualpai region (7,400 ft.) in north-western Arizona. The Kitt Peak site is of special interest because it is on the Papago Indian Reservation. The mountain is sacred to the Papagos and the Papago Tribal Council granted special permission for the erection of a 'seeing' tower. Similar towers will be erected on other sites, including the Junipero Serra, California.

European Bison from Poland

THROUGH the Forestry Commission, Poland has generously presented to the United Kingdom a breeding pair of European bison. They arrived on October 9 and are in the London Zoo for a period of quarantine; afterwards they will be on show to the public and may later be transferred to Whipsnade. European bison are rare forest animals and, until the arrival of the pair from Poland, the Zoological Society had none in its care. Poland has between eighty and ninety European bison, representing, it is understood, a substantial proportion of world stocks; the pair now in Britain are from a reserve near Cracow.

Bristol Museum

THAT the Bristol Museum plays an energizing part in the cultural life of the city and surrounding county is shown in the report of the city's Museum Committee for 1955. Although the main activities of the Museum are linked to the permanent exhibits, fifteen major temporary exhibitions were also arranged; these ranged from geology as illustrated by railway posters to a collection of postage stamps issued in the nineteenth century. A special feature is arranged each month to show either objects on loan or recently given. The city archivist has provided material each quarter for a special case while the city librarian exhibits local documents of topical interest. The Bristol Society of Architects has devised illustrations which enable visitors to understand and appreciate the principles of architecture, examples being drawn from the locality. As in previous years, six lectures have been provided during the winter months to audiences of more than three hundred at each session. Conducted summer walks have again been arranged, some of the walks attracting so many visitors that they have been embarrassing to conduct. The staff of the Museum was again invited to give many lectures to various organizations, while an interesting development was the loan of small assemblages of zoological and botanical material to H.M. Prison at Falfield. Classes from all types of schools have visited the Children's Room. The demands in history and natural history are now approximately equal; but although the room is in constant use during term-time, requests exceed the number which it is possible to accommodate. The Saturday Nature Club, now more than a year old, has been enthusiastically attended by 50–60 members each week, chiefly older primary school children. This is a record of which Bristol Museum might well be proud and should serve as a model for other areas.

Trinidad and Tobago Forest Department: Report for 1954

THE annual report for 1954 of the Trinidad and Tobago Forest Department (pp. 44+1 map. Trinidad: Government Printing Office, 1955; 36 cents) gives a statement of the present areas of forestry in the Islands. Their total area amounts to 1,863 and 116 square miles, respectively, practically all of which is below a thousand feet. In Trinidad and

Tobago forest reserves now cover 279,996 acres, or 22 per cent of the country. To this about 65,000 acres of hill forest will be added when the surveys have been completed, bringing the total to 27 per cent. Adjustments are probable later, and it is assumed that the forest estate will eventually be about 300,000 acres—a very satisfactory area for the Islands. Of this area, 64,000 acres have been allocated to the plantation programme, mainly teak (an exotic, of course), and about 100,000 acres, parts of which have not yet been declared forest reserves, may be found to be inaccessible for a long period. Swamps cover a certain amount of area. Thus there are 128,000 acres of accessible forest to be regenerated under systems other than teak and mixed hardwood plantations. In the north a natural regeneration programme is in force over 31,800 acres, which will be treated under the shelter-wood system. In general, the forest management in the Islands may be considered to be in a satisfactory state.

André Mayer Fellowships of the Food and Agriculture Organization

The United Nations Food and Agriculture Organization has established a number of fellowships for advanced training in preparation for research work in topics of particular interest to member countries and to the Organization as a whole. Five or six fellowships are being offered this year, spread over the whole field covered by the Organization, namely, agriculture, agricultural economics and statistics, fisheries, forestry and nutrition. They will be called André Mayer fellowships in memory of the late André Mayer, who was closely associated with scientific research in France as well as international work, particularly in relation to the Organization. The awards will be for periods up to two years, with the possibility of an extension to a maximum of thirty months, and payment will be about 250 dollars a month. Further information can be obtained from the Secretariat of the F.A.O. National Committee for the United Kingdom, c/o Ministry of Agriculture, Fisheries and Food, 10 Whitehall Place, London, S.W.1.

Scottish Postgraduate Scholarships in Agriculture

The Department of Agriculture for Scotland has awarded the following postgraduate scholarships in agricultural subjects, tenable for periods up to three years at the institution shown: *Husbandry*, R. C. Kirkwood (University College of Wales, Aberystwyth), A. McKechnie (University of Reading), and J. L. Beveridge, S. S. Fluss and C. G. M. Duncan (University of Cambridge); *Engineering*, D. A. Jack (King's College, Newcastle upon Tyne). The awards held by the following, all of which are in husbandry, are being continued for a further period: A. D. Drysdale (University of Minnesota), D. M. S. Livingston (University of Aberdeen), C. Smith (Iowa State College), R. A. N. Napier (University of Edinburgh), J. Frame, I. C. Beattie and W. C. Smith (Massey Agricultural College, New Zealand), and N. C. Lawson (Macdonald College, McGill University).

Announcements

Major C. W. Hume, director of the Universities Federation for Animal Welfare, which he founded originally in 1926 as the University of London Animal Welfare Society, has been awarded the Albert Schweitzer Medal of the American Animal Welfare Institute.

Dr. R. Lessing has been elected president of the National Smoke Abatement Society in succession to Sir Ernest Smith.

The following appointments in the University of London have been announced: Mr. P. V. Danckwerts, deputy director of research and development of the Industrial Group, Atomic Energy Authority, to the University chair of chemical engineering science tenable at the Imperial College of Science and Technology; Dr. H. Tropper, senior lecturer at Queen Mary College, to the University readership in electrical engineering tenable at that College.

Dr. D. Starkie, director of research at the Hosiery and Allied Trades Research Association, is relinquishing his appointment in order to join the Board of English Rose, Ltd., as director of research in charge of the newly created Department of Research. Dr. Starkie will head a team of experienced scientists and technologists and will be concerned with research on hose materials, machines and products.

The sixth George Scott Robertson Memorial Lecture, given under the auspices of the Ministry of Agriculture, Northern Ireland, will be delivered in the Sir William Whitla Hall of The Queen's University, Belfast, at 3 p.m. on October 26, by Dr. D. P. Cuthbertson, director of the Rowett Research Institute, Aberdeen. The subject will be "Animal Nutrition in relation to Production and Disease". The Lecture will be open to the public.

The programme of lectures for 1956–57 of the Bedson Club, King's College, Newcastle upon Tyne, is as follows: October 26, modern inorganic stereochemistry, by Prof. R. S. Nyholm; November 16, the chemistry of some naturally occurring polyacetylenes, by Prof. B. Lythgoe; and January 25, polymerization in heterogeneous systems, by Prof. C. E. H. Bawn.

The first meeting of the British Society for Immunology will be held at the Wellcome Foundation, 183 Euston Road, London, N.W.1, during November 9–10. Following introductory remarks by Sir Henry Dale, the meeting will consist of the reading of scientific papers, the afternoon of the first day being devoted to a symposium on "Complement". Further information can be obtained from Prof. G. Payling Wright, Department of Pathology, Guy's Hospital Medical School, London, S.E.1.

The Morcom Green, Edwards Prize, which is offered yearly through the New Zealand Institute of Chemistry for the encouragement of original research by younger chemists, has been awarded this year to I. R. C. McDonald, of the Dominion Laboratory, Department of Scientific and Industrial Research, New Zealand, for his work on methods for the analysis of insecticides used in agriculture. Mr. McDonald has been engaged in the analysis of complex organic mixtures, with particular emphasis upon wool fat, insecticidal mixtures and wood chemistry, and has developed original techniques, using a double-beam infra-red spectrophotometer, for determining accurately the proportions of the toxic substances present in insecticide formulations.

Erratum. In *Nature* of August 4, p. 240, it was stated that Dr. F. Kőrösy had been appointed professor of physical chemistry in the Technion–Israel Institute of Technology, Haifa; he has, in fact, been appointed research fellow in physics at the Technion.

PHYSIOLOGICAL AND CELLULAR ASPECTS OF AGEING

A VARIETY of interesting papers were read at a joint meeting of the Dutch Society of Gerontology and the British Society for Research on Ageing, held at the Antoni van Leeuwenhoek-Huis (Netherlands Cancer Institute), Amsterdam, on July 27 and 28. Included in the programme were papers by guest speakers from the United States, Canada and South Africa.

One of the difficulties in studying morphological or physiological changes with old age has been that of distinguishing between fundamental alterations due to senescence and changes due to the operation of secondary factors, for example, nutrition. Dr. J. J. Groen, of Amsterdam, described a condition, 'senile' paradentosis, which might have been thought at first to have been in either category. This condition is characterized by resorption of the alveolar bone of the tooth sockets, usually accompanied by retraction of the gingiva; it is progressive and leads eventually to loss of teeth and to extensive atrophy of the jaw. The condition may begin in the young or middle-aged. Another condition well known in old people is senile osteoporosis, particularly in the spine and pelvis. This condition is clinically recognizable by X-rays; but it produces remarkably few metabolic changes. The phosphorus, calcium and phosphatase of serum of such patients seem to be unchanged, and the cause of the condition has been the subject of much speculation. Until recently, osteoporosis has been recorded by physicians and paradentosis by dentists—but Dr. Groen believes that they are one and the same disease. His investigations showed that all those suffering from one of them were found upon investigation to be suffering also from the other.

The etiology of this complaint was investigated at some length; but only one constant factor could be found—in all cases the patients were people who had stopped taking milk at an early stage in their lives. Investigation of their diets, which seemed adequate in most nutrients, showed a calcium intake between 250 and 450 mgm. per day. A few patients on whom balance studies were done while they were on their 'home diet' had negative calcium balances of 50 to about 200 mgm. a day. Control individuals who drank a pint to a quart of milk a day showed scarcely any sign of paradentosis or of osteoporosis at an advanced age.

Dr. Groen pointed out that Allbright had thought that osteoporosis in old persons was due to a decrease in sex hormones; but his own investigations had shown that the disease can occur before the menopause and is invariably associated with a long-protracted low intake of calcium. He believes, in fact, that the condition 'paradentosis–osteoporosis' is mainly a result of a chronic, low-grade calcium deficiency.

Dr. T. Gillman, of South Africa, also recorded the syndromes of many nutritional conditions met with in South Africa among native populations. These included kwashiorkor, pellagra and an accumulation of iron in the liver which was sometimes followed or accompanied by fibrosis; he stressed the significance of his results in the study of gerontology.

Clinical studies on blood pressure by Dr. M. Landowne, of Bethesda, using intra-arterial recording, showed that the systolic pressure increases by an average of 4·8 mm. of mercury or 4 per cent per decade. This is the momentary peak pressure; but the average increase of the entire systolic period is 2·8 mm. mercury or 2 per cent per decade. There is also a decreased cardiac output of 1 per cent per year due partly to decrease in the blood pumped by each beat. Portion of this decrease is effected by a slowing of the heart. Just as in training for athletic activities the heart-rate slows, so in old age it slows as an adaptive change, for by so doing there is a large diastolic filling period, thus providing a better stroke/volume than if the diastolic pressure was shortened.

Dr. R. Van Zonneveld, of Gröningen, described a survey of old persons in the Netherlands which began with an inquiry among the old people themselves as to how they felt and what infirmities they complained of. This is to be followed by an announcement of the details of a survey which will be carried out in collaboration with twenty-four regional teams of doctors.

The question of whether sex hormones are invariably decreased in old age was discussed by Dr. O. Mühlbock, of the Netherlands Cancer Institute, on the basis of his work on highly inbred mice. Frequently in old female mice an enormous hypertrophy of the uteri is observed. It was found that the œstrogenic hormones maintaining this uterine development are produced by the ovaries. These old ovaries show few follicles; but cells can be seen in the periphery, obviously coming from the germinal epithelium, which look very like granulosa cells. They penetrate into the ovarian stroma forming small anovular follicles which are probably the source of at least some of the female sex hormone. In some cases the adrenals too may contribute œstrogens in old mice. In old adrenals so-called 'A' cells develop just under the cortex. These cell groups may show adenomatous development, and in this case probably also produce œstrogens.

In some animals there is also an enormous development of the mammary glands. This may be in part due to female sex hormones, but also to the high production of prolactin by the old pituitary. It was found that these mice often had pituitary tumours of a similar nature to those which can be produced in younger animals by prolonged œstrogen treatment. These pituitary tumours contain no gonadotrophin, growth hormone or corticotropin, and only a little thyrotrophic hormone. A high prolactin activity is, however, regularly found.

These studies emphasized that hormone imbalance may occur in old age, leading to endocrine hyperactivity rather than inactivity in some cases, and that this appears to be genetically determined.

Kidney studies of old rats by Dr. and Mrs. Friedman, of Vancouver, also demonstrated endocrine changes in old animals. In this case it is apparently decreased neurohypophysial function which is responsible for their results. They found that both young and old animals appear to excrete sodium

identically, but that the older animals excrete a much more watery urine which suggests a decrease of the tubular water-absorption mechanism. If 'Pitressin' is given to the old animals with the saline solutions used in producing a salt load on the kidneys, re-absorption of water becomes the same as in the young animals, although sodium re-absorption was a little less. The neurohypophysis was shown to be unresponsive to direct osmotic stimulus in the old rat.

Cellular and tissue studies in old age were described by Dr. P. J. Thung, of the Netherlands Cancer Institute, Dr. G. H. Bourne, of London, and Dr. H. Saxl, of the Department of Medicine, Leeds.

Dr. Thung's paper dealt with amyloidosis in senile mice. He pointed out that mice easily develop amyloid, which may be produced experimentally in response to injection of a wide variety of substances and even by a milk and cheese diet. In old age, however, untreated mice similarly often develop amyloid. Genetical factors appear to be of prime importance in this tendency to amyloid degeneration, both experimentally and spontaneously, as some strains are rarely affected whereas others may show a 100 per cent incidence. Many of the substances which in mice cause amyloid, in the rat produce only necrosis and fibrosis. Similarly, it was found that chronic alcoholism, which in man would be expected to lead to liver cirrhosis, in mice caused heavy degrees of amyloidosis of the liver.

In human pathology it is increasingly recognized that amyloid degeneration is far more frequent than the classical condition found secondary to chronic suppurative disease. Its various forms range from this secondary amyloidosis to the amyloid found in cases of rheumatoid arthritis and the amyloid infiltrations frequently observed in the cardiac muscle in old age. These forms apparently represent different varieties of a common derangement of protein metabolism, on the causes of which as yet little is known. In mice, however, this derangement occurs much more easily than in man, and the causative agents consequently are less specific. Among these, old age plays an important part.

Dr. G. H. Bourne described the principal changes that take place in cells as they age, and directed attention to the fact that in many organs in old animals there is a histochemical increase in the activity of phosphatases and esterases and that biochemical studies have recorded an increase in activity of other hydrolytic enzymes. It may be that this increase in hydrolytic enzyme activity, which is destructive of many esters essential in metabolic activities, is one of the fundamental changes taking place in ageing cells.

The question of a possible link between protein and polysaccharide involvement in arteriosclerosis and lipid metabolism was discussed by Dr. H. Saxl, of the Department of Medicine, Leeds. She suggested the following mechanism by which the tissue polysaccharides *in situ* and certain components of the serum form an anti-lipæmic system: (*a*) in the presence of elastase, and especially the fraction which appears to have elasto-mucase activity, the muco-polysaccharides are made soluble and unstable; (*b*) the action of the serum inhibitor is to inhibit the removal of the soluble polysaccharides and by a direct action on these to make them stable and orthochromatic, and either secondarily or as a result of this interaction to activate a lipase.

An examination of the mode of the lipolytic action on atheromatous arterial walls has shown that there appear to be a degradation of neutral lipids of the atheromatous plaques and liberation of the soluble acid fats, which diffuse in the tissues.

G. H. Bourne

CHEMISORPTION

SYMPOSIUM AT KEELE

A SYMPOSIUM on chemisorption was held by the Chemical Society during July 16–19 in the University College of North Staffordshire, Keele. The symposium, which was organized by Prof. W. E. Garner, was divided into five sections, the first of which dealt with the theory of chemisorption, with Prof. Garner as chairman. D. A. Dowden (Billingham) gave a general review of the covalent aspects of adsorption, extending the usual classification of *sp* and *d* bonds from metals to semiconductors. He considered that adsorbed gases could either be held strongly on the intermetallic type of *dsp* orbitals, or more weakly on atomic *d* orbitals. Using the ideas of crystal field theory, he indicated how the d^2sp^3 orbitals of a surface metal atom might split to give a d^2p set for the underlying metal and a *dsp* orbital in the surface. He did not consider that the surface metal atoms exhibit *dsp* free valencies, but emphasized the role of *dz* orbitals in weak adsorption. T. B. Grimley (Liverpool) used the *L.C.A.O.* or tight-binding approximation to discuss the interaction of a hydrogen atom with an electron in a surface state of the metal. Where a singly occupied surface state or partly occupied *d*-band is available, a bond is to be expected, the hydrogen atom being located over the metal atom. J. H. de Boer (Geleen) gave a critical account of theories relating heat of adsorption to surface coverage, and contact potential. He considered particularly the cases of cæsium on tungsten and hydrogen on nickel. The deficiencies of the simple double-layer theory were described and then improvements, allowing for discrete layers and mutual depolarization of dipoles, were tried. The conclusion reached was that some heterogeneity was present even with cæsium on tungsten. G. C. A. Schuit, L. L. van Reijen and N. H. de Boer (Amsterdam) described thermodynamic data for the adsorption of hydrogen on nickel supported on silica, and other supported transition metals. Definite evidence for heterogeneity was deduced, and experiments on the hydrogen–deuterium exchange showed the existence of a few sites specially active at 77° K. In the discussion, the thought was expressed that the silica support might in some way be contributing to the heterogeneity observed.

The next section dealt with chemisorption on insulators, and the chair was taken by D. A. Dowden. J. J. Kipling and D. B. Peakall (Hull) described results on the adsorption of liquids on silica gel and alumina. Four tests were made to distinguish chemisorption from physisorption: irreversibility; time effects; evidence for reaction at specific sites; and the relation of extent of chemisorption to the number and nature of active groups in the surface. S. J. Gregg (Exeter) described how some water was retained by active oxides even at the highest temperatures, probably hydroxyl groups. A second variety of adsorption, probably involving molecular

water that was hydrogen-bonded to the surface, was indicated by the failure of desorption isotherms to close with the adsorption isotherms even at the lowest pressures. The presence of some hydroxyl groups appears essential for this type of adsorption. If silica is heated to 600° C. it becomes hydrophobic, showing a type V isotherm, but becomes hydrophilic when exposed until half saturated with water vapour. A. Kloosterziel (Amsterdam) described results on the interchange of deuterium atoms between alumina containing deuterium and ethylene. His kinetic analysis was developed in great detail for a number of possible models, to give the distribution of deuterium over the ethylene molecules as a function of time of contact. His conclusion was that, in the exchange process, two ethylene molecules require to be adsorbed at one site, probably an Al^{3+} ion. Subsequent discussion on these papers brought out the fact that physical and chemical adsorption frequently overlap in energy and that it is undesirable to try to draw too firm a dividing line.

The third section dealt with chemisorption on metals, and the chair was taken by Prof. D. D. Eley. B. M. W. Trapnell (Liverpool) reviewed his recent work on evaporated metal films and showed how heats of adsorption of oxygen and hydrogen on a range of metals may be related by a single numerical factor. A correlation of adsorption heats with atomic number for a series of metals appears to be more satisfactory than a correlation with *d*-character. This he related to the properties of the free atom, the states of which, he suggested, resemble the surface states of a bulk metal. The reactivity of gold and mercury in oxygen chemisorption so far stands outside all such schemes. He outlined new data on velocities of chemisorption on ten metals, and related them to exchange velocities of hydrocarbons (W, Rh > Pd > Ni > Fe). R. Suhrmann (Hanover) reviewed his results on changes in electrical resistance brought about by adsorption of gases on thin films of nickel and bismuth, the latter metal being chosen since its films show semiconducting properties. As an example of his work, he found that hydrogen on adsorption increases the resistance of nickel films at 90° K. On bismuth hydrogen effects only a very small decrease of resistance, attributed to a polarization $H_s^+ \ldots Bi^-$. The paper by J. C. P. Mignolet (Liège) dealt with the problem of charge transfer in physical adsorption, as revealed by the author's extensive results on contact potential changes brought about by adsorbed gases. Thus in a case like nickel–xenon (0·85 V.) he concluded that the *d*-orbitals of the nickel are the acceptor orbitals. Where these are not present, smaller effects are observed, for example, zinc–xenon (0·21 V.). The method may be used as a diagnostic test for empty surface *d*-orbitals and reveals their presence in copper, since copper–xenon is 0·67 V. G. C. Bond and J. Addy (Hull) described results on the addition of deuterium to cyclopropane. The distribution function for deuterium in the products is considered to give a measure of the catalytic activity, the metals in descending order being rhodium, iridium, platinum, palladium, nickel. The paper by D. D. Eley and D. R. Rossington (Nottingham) gave a kinetic analysis of the parahydrogen conversion on a copper film which led to a value of 8 kcal. for the heat of chemisorption. Apparent frequency factors and activation energies were determined for copper, silver and gold catalysts in the form of foil, film and wire. The apparent activation energies were constant for a given metal, but the frequency factors increased in the order: foil, film, wire. The results for the three metals fell on a logarithm (frequency factor)—*E* relation that is characteristic of the catalyst type. The paper by P. M. Gundry and F. C. Tompkins (London) dealt with the slow adsorption of hydrogen and carbon monoxide on nickel. They found the Elovich equation applicable, and proposed a model of a homogeneous surface, with sites of strong adsorption reached via precursor sites of weak adsorption, linking up with Dowden's *d*-orbital model. J. H. Leck (Liverpool) described the effects of positive ion bombardment on metal surfaces. The positive ions were found to penetrate the surface to a depth of several atoms. In the discussion, D. J. C. Yates (Cambridge) outlined infra-red evidence for the loss of rotations by methane on adsorption on silica.

Prof. W. F. K. Wynne-Jones took the chair for the fourth section, which considered chemisorption on carbon. D. J. E. Ingram (Southampton) described the application of the electron resonance technique to the problem of carbonization. There is clear evidence for high concentrations of trapped electrons, apparently sited around the edges of condensed rings. On absorption of oxygen, the concentration of electrons and their delocalization are both decreased, the effect being reversible. A. Harker, A. Marsh and W. F. K. Wynne-Jones (Newcastle) described results on the physical and chemical structure of carbons. Oxygen chemisorption was shown to be markedly affected by hydrogen atoms and metal atoms in the main carbon structure. J. F. Goodman (Cambridge) outlined investigations on the effect of adsorption of oxygen on carbon carried out in Dr. F. P. Bowden's laboratory. They lead to the view that oxygen, by adsorbing between the carbon sheets, lowers the electron density and hence the cohesion between the sheets.

The final section, under the chairmanship of Dr. F. S. Stone, dealt with semiconductors. Dr. Stone's introduction defined *n*- and *p*-type semiconductors, and outlined the results of electron transfer and barrier-layer theory. The saturation coverage of gas is very low (less than 5 per cent) where barrier layers are operative, but in other cases—for example, carbon monoxide and hydrogen on zinc oxide—saturation occurs at high coverages and covalent bonds are probably formed. He described the work of Kubokawa, which has shown how hydrogen may be absorbed on zinc oxide below 110° with no effect on semiconductivity. According to R. Morrison, this may be explained by reaction of hydrogen with chemisorbed O^- species. Ionic processes may also be of importance—for example, in cases such as oxygen on cuprous oxide, calcium oxide and uranium oxide —where surface coverages less than 1 are found.

The next speaker, P. T. Landsberg (Aberdeen), emphasized the experimental criteria necessary for a decision on barrier-layer theory in a specific case. E. R. S. Winter (Birmingham) described the results of oxygen-18 exchange between oxides and various oxygen-containing gases, reviewing earlier work and presenting new data. In many cases the activation energy fell to a lower value at higher temperatures, corresponding to a change-over of the rate-determining step from dissociative adsorption to lattice exchange. Evidence was brought forward to show that the decomposition of nitrous oxide on nickel oxide proceeds on a small fraction of sites and involves the participation of lattice oxygen. Similar results hold for the carbon monoxide–oxygen reaction; but a

different set of sites is involved. R. Rudham and F. S. Stone (Bristol) described the chemisorption of oxygen, carbon monoxide and carbon dioxide on cuprous, nickel and cobalt oxides, correlating observed heats with reversibility and surface coverage. Oxygen chemisorption was activated and extensive, exceeding the monolayer in cuprous and cobalt oxides, and this is probably a general effect for oxygen on *p*-type semiconductors. J. D. M. McConnell and L. E. J. Roberts (Harwell) considered adsorption of gases on uranium dioxide and thoria. Oxygen is considered to adsorb on the uranium ion, accepting electrons from the solid, while a carbon monoxide molecule donates electrons to a uranium or thorium ion. There is evidence for an autocatalytic adsorption of oxygen on uranium oxide, analogous to that observed by Dowden and Beebe in 1938 with chromia, and this point raised some discussion. The final paper, by R. J. Davis (Fulham), showed how antiferromagnetic interactions in the cation lattice of α-Cr_2O_3, V_2O_3 and other oxides affect the unit-cell dimensions. He considered that these cation–cation interactions might be involved in the chemisorption of hydrogen, and in ring-closing reactions of hydrocarbons.

The meeting was exceptionally well attended, the discussions were lively on most topics, and the arrangements made by Prof. H. D. Springall and the University College all helped to make the symposium a considerable success. The proceedings of the symposium are to be published in the near future by Butterworths and Co. (Publishers), Ltd.

D. D. Eley

PROGRESS IN RADIOBIOLOGY

CONFERENCE IN STOCKHOLM

THE Fifth International Conference on Radiobiology met in Stockholm during August 15–19, under the chairmanship of Prof. George de Hevesy. About 180 scientists from nineteen countries were present, and eighty contributions read and discussed. In comparison with previous meetings, emphasis was placed more on the hæmopoietic and genetic effects of radiation, and less on its primary physical or chemical action.

During the past year, it was shown that hæmopoietic cells injected into heavily irradiated animals of the same, or even of a different, species can colonize the blood-forming tissues of the hosts. This explains how animals can survive lethal doses of radiation if part of their blood-forming tissue is shielded, or if they receive after irradiation an injection of hæmopoietic cells of another animal. The hypothesis that recovery is promoted by some humoral or subcellular factor is now unnecessary, and at this meeting it was reported that the 30-day survival of *CBA* mice after 950 r. depends on the number of intact spleen cells inoculated, and is independent of the number of nuclei of damaged cells (D. W. H. Barnes, M. P. Esnouf and L. A. Stocken). The effectiveness of a given inoculum is greatest when the graft is least different genetically from the host (J. Soska, V. Drasil and Z. Karpfel; J. A. Cohen, O. Vos and D. W. van Bekkum). After 950 r. whole-body irradiation to mice and subsequent injection of spleen cells, the entire blood-forming tissue was taken over by the graft. No reversions to tissue of host origin were observed up to 157 days after grafting from another mouse. With heterologous (rat) grafts, reversion may occur (C. E. Ford, J. L. Hamerton, D. W. H. Barnes and J. F. Loutit).

Of medical interest was a more sensitive assessment of hæmopoietic damage in persons exposed to low occupational doses, by means of a new method of collecting and treating blood-count data (M. Helde). The great sensitivity of red-cell precursors was seen after 50 r. whole-body X-irradiation of rats, when the number of late and intermediate normoblasts in the bone marrow fell to less than 50 per cent in 24 hr. (E. V. Hulse). It now seems established that exposure to radiation increases the risk of leukæmia in man (W. M. Court-Brown). Study of 828 case histories of leukæmia from the Danish cancer register (M. Faber) leads to the conclusion that both chronic myeloid and acute leukæmia can be induced by radiation, and that part of the increased incidence is due to diagnostic X-ray procedures in which bone marrow is exposed. The absorption, retention and removal were described of the decay products of radium and thorium (K. Aurand, W. Jacobi and A. Schraub), of strontium-90 in bone (M. Owen and J. Vaughan) and of yttrium (R. Lewin, B. Rosoff, H. Hart, K. G. Stern and D. Laszlo).

Work done on chemical protectors has failed to reveal a common mechanism for their action. Some earlier observations on cysteamine have not been confirmed (Z. M. Bacq). It was ineffective when given to chicks or administered orally to rats. It was suggested that cysteine and cysteamine act by inducing anoxia (J. F. Duplan and H. Marcovitch; J. A. Cohen, O. Vos and D. W. van Bekkum). Cysteine protected *Glis glis* from mortality if administered twenty-one days after irradiation, provided the animals were kept meanwhile at 4° C. in their hibernating state (H. Künkel, G. Höhne and H. Maass). It is difficult in this case to see how the protector could interfere with primary radicals or exert its influence by specific reactions involving —SH or —S—S— groups of target molecules (A. Pihl and L. Eldjarn; U. Hagen). We are reminded of the specificity of protectors by the fact that α-thiolamino-acids are protective, whereas β-thiolamino-acids enhance radiation effects in mice (R. Koch). Dose-reduction factors of cysteamine and of β-aminoethyl*iso*thiouronium change with the dose of radiation. Critical damage is thought to occur at different sites after different doses, and the efficiency of protection to vary from site to site (A. Catsch).

Among agents which increase radiosensitivity, oxygen has retained its interest. The sensitivity of *E. coli* irradiated in buffer solution increased with oxygen concentration in the bubbling gas, and reached almost full sensitivity at 3 per cent oxygen (T. Alper). The sensitivity change in Ehrlich ascites tumour cells from anoxia to full oxygenation occurs at lower concentrations of oxygen than previously reported (O. C. A. Scott), and a similar pattern of sensitivity was found in the ascites form of the Yoshida rat sarcoma (W. Dittrich). The sensitivity typical of the anoxic state was attained 3 sec. after stopping the circulation in mouse tails (P. Howard-Flanders). Cooling mice to 0–0·5° C. afforded a dose-reduction factor of 2·8, an effect largely attributed to the anoxic condition of hypothermic animals (S. Hornsey). Organic peroxides produced by X-rays seem to be implicated in mutagenesis in *Drosophila*, since it is potentiated by pretreatment with dihydroxydimethyl

peroxide or formaldehyde, or with cyanide or azide (F. H. Sobels).

The question of the contributions of the direct and indirect effects to biological damage received some attention. The direct effect in polythene and dry bovine serum can be influenced by oxygen or temperature, but seems to be independent of small amounts of water (P. Alexander). In contrast, it was claimed that the radiosensitivity of enzymes in wet yeast cells is 2–50 times higher than in dry cells, suggesting a high contribution from the indirect effect (F. Hutchinson).

The respiratory system of mouse-liver slices is affected by doses higher than 10^6 r. Sensitivity is determined by cytochrome *c*, which is destroyed by indirect action (B. Rajewsky, G. Gerber and H. Pauly). Yoshida ascites cells 20 min. after 20,000 r. show a drop in respiration and in aerobic and anaerobic glycolysis, and changing relative levels of adenosine di- and tri-phosphate. These differences become less pronounced at 40 min. (G. Höhne, H. A. Künkel and H. Maass). Incorporation of *dl*-phenylalanine-^{14}C into cell components of mouse liver is higher after 500 r. whole-body exposure (J. A. V. Butler, P. Cohn and A. R. Crathorn). The rate of incorporation of phosphorus-32 into rat thymus deoxyribonucleic acid is reduced to half within 3 min. after 1,000 r. to the whole body (M. G. Ord and L. A. Stocken). Increased incorporation of tracers after irradiation may be due to reduced size of body pool (F. Sherman and A. B. Almeida).

A single sub-sterilizing dose of 1,050 r. given to rabbit ovaries is less damaging to late primordial follicles than if given in fractions of 210 r. every 48 hr. (P. Desaive). The sterilizing dose for female mice, on the other hand, does not seem to be dependent on dose-rate, whether delivered at 2·5 r. daily or in one exposure (H. and U. Langendorff).

In a session on genetic effects in *Drosophila*, H. J. Muller and I. I. Oster presented new evidence that true reversals of the original forked (*f*′) mutation can be induced by X-rays. They believe that point mutations of whatever origin are indistinguishable in principle, and are due to qualitative chemical changes in the gene locus. Alkylating agents were reported to have produced a large number of point mutations in loci that have not been observed to mutate under X-irradiation, and the distribution of chemically and X-ray induced mutations on the *X*-chromosome has been found to vary with the mutagen used (O. G. and M. J. Fahmy). Chromosomes of spermatids are at least twice as sensitive to the X-ray induction of lethals and translocations as those of mature sperm in inseminated females (I. I. Oster). Crossing-over in spermatogonia can be induced by injection of formaldehyde (F. H. Sobels). Chromosome breaks, and possibly also intragenic changes, induced by X-rays in mature sperm, are thought to undergo recovery if the sperm are retained for one day in the male (K. Nordback and C. Auerbach). At least five times as many small-effect detrimental mutations as recessive lethals are induced in male *Drosophila* by X-rays (K. G. Lüning and S. Johnsson). The reduced viability of flies receiving irradiated chromosomes is accompanied by a decreased rate of development, and it was suggested that growth-rate studies might be useful in assessing genetic damage due to radiation in mammals (G. Bonnier).

Two films were shown illustrating the effect on mitotic behaviour of irradiating parts of cells in tissue culture with α-ray microbeams. Sensitivity increased by a factor of 10 from prophase to metaphase (M. I. Davis, I. Simon-Reuss and C. L. Smith), and irradiation of chromosomes was much more effective in producing anaphase and telophase abnormalities than irradiation of cytoplasm only (R. Munro). When roots of *Vicia faba* are irradiated with very high intensities of X-rays, in the range 600–1,200 r./min., a class of chromosome breaks becomes apparent which rejoin very rapidly and which may be due to breakage of ionic bonds. These breaks are to be distinguished from those others, regarded as due to the breakage of co-valent bonds, which remain open for a relatively long time (S. Wolff).

Under the appropriate chairmanship of Prof. Å. Gustaffson, a special session met on the last day to discuss the application of the mutagenic effects of radiation to plant breeding. Facilities and techniques were described for the Brookhaven Laboratory (H. J. Curtis) and plans outlined for the improvement of the rice crop in India (A. R. Gopal-Ayengar). Of 427 radiation-induced mutations in soya beans, only 1 per cent seem to be of some economic value (M. Zacharias). In black currants, selection of mutated shoots from irradiated cuttings was reported to have given promising results (R. Bauer). A review was given of the work of the Swedish group in utilizing 'directed' mutations produced in barley by various physical and chemical agents (D. von Wettstein).

Michael Ebert
Alma Howard

POPULATION GENETICS

A SYMPOSIUM on population genetics, with particular reference to stability of development, was held on the afternoon of Monday, September 3, at a joint session of Sections D (Zoology) and K (Botany) of the British Association in Sheffield. It was opened with a paper by Dr. J. M. Thoday entitled "Environmental Heterogeneity and the Genetic Architecture of Populations". Dr. Thoday began by pointing out that one of the most remarkable discoveries of recent biology was the great diversity of genotypes to be found in any population of out-breeding species. Comparative uniformity of individual morphology is mediated by a wide range of genotypes, each highly heterozygous and compounded of chromosomes many of which, though successful in heterozygous combinations, are deleterious, or even lethal, if made homozygous. This great genetic heterogeneity of populations is generally held to find its explanation as an adaptation permitting populations to survive change of their environment. Nevertheless, the heterozygosity on which this individuality depends involves a price, for it necessarily involves the production of some segregants poorly adapted to contemporary environmental conditions and, hence, involves relative infertility. The out-breeding systems by which heterozygosity is maintained are also less secure than self-fertilization. Some scientists therefore find it difficult to believe that the long-term selection for heterozygosity can be powerful enough to over-ride the short-term selection for fertility, and therefore doubt whether it is sufficient as an explanation of the ubiquity of the cross-breeding systems that maintain heterozygosity. Dr. Thoday suggested that if we consider the nature of environment heterogeneity, we find reason to believe that selection for

heterozygosity on a relatively short-term basis may be strong. Environmental heterogeneity may be classified as random, directional or cyclic, the latter being the type to which he gave most attention. If the period of the cycle is longer than generation time, then the cycle will involve selection for new genotypes each generation and periodic reversal of the direction of selection. In these circumstances, a population may be expected to become heterozygous for genes appropriate to peak and trough conditions of the environmental cycle. Further, a certain degree of heterozygous advantage is to be expected as a system buffering the population against loss of peak genes in trough conditions, and vice versa. This system is precisely that known to occur in populations of *D. pseudoobscura* studied by Dobzhansky. Superimposed on the system, and hence in a heterozygous context, selection will proceed further to produce *individuals* capable of withstanding a longer and larger proportion of the range of environmental conditions imposed by the cycle. Only the success of this form of evolution can permit the evolution of longer generation times, and the end will be heterozygous individuals that can withstand the whole cycle and hence perhaps live for several cycles.

Dr. Thoday suggested that our finding that the ability of individuals to control their development despite environmental variation very often depends on heterozygosity may well be explicable in terms of such a history of adaptation to cyclic conditions which he attempted to show are ubiquitous, especially since spatial differentiation of the environment must produce cyclic conditions in time, as dispersal of seed, etc., works in both directions.

The remaining papers were all concerned with this ability of individuals to maintain organized 'normal' development despite internally or externally caused disturbances. Mr. J. A. Beardmore reported on the effects of a diurnal temperature cycle on stability as measured by bilateral asymmetry of sternopleural chæta number in *Drosophila melanogaster*. Two long inbred lines the inbreeding history of which had occurred at constant 25° give more stable F_1 hybrids at 25°, the F_2 flies being, if anything, more stable than the F_1. In the fluctuating temperature conditions (mean 25°, midnight 20°, midday 30°), the reverse result is found, the F_1 being less stable than the inbreds and the F_2, if anything, less stable than F_1. He also reported evidence that though laboratory flies from constant-25° rooms are usually less stable in the fluctuating than in the constant-temperature incubator, newly captured wild flies give offspring superior in the fluctuating condition, indicating this to be the nearer to a wild environment. Six months in constant laboratory conditions may be sufficient for populations to lose their relative adaptation to the fluctuating condition. Experiments on natural populations involving comparisons in constant temperatures have therefore to be interpreted with caution.

Mr. J. Maynard Smith followed with a paper entitled "Developmental Flexibility in *Drosophila*". He began by stressing the point that the degree to which the development of organisms is under control or stabilized is not always to be measured by the degree of uniformity of the end product. Sometimes fitness may require different phenotypes in different environments. The superior capacity of outbreds, as compared with inbreds, is usually deemed demonstrated when it is shown that the outbreds are more uniform than corresponding inbreds; but when the situation is such that optimum phenotype varies with environment, then the best-regulated development should lead to variation of phenotype corresponding to variation of environment, and in these conditions, if outbred individuals are superior to inbreds, they should vary more than inbreds.

Mr. Maynard Smith described his attempt to test this hypothesis in *Drosophila subobscura*. The character measured was the length of time for which adult flies could survive at 33·5° C. in dry air. Three inbred lines and the three hybrid populations between them have been tested. In all three hybrid populations, individuals which were kept at 25° C. as larvæ and pupæ, and then at 15° C. as adults for a week before testing, lived approximately 2·5 times as long as did individuals of the same genotype kept at 15° C. throughout. Thus outbred individuals are capable of long-lasting acclimatization to high temperatures if they are kept at 25° C. during the pre-adult stages. Of the three inbred lines, one showed no capacity for acclimatization, and the other two acclimatized significantly less than did the hybrids. Thus the capacity to withstand exposure to high temperatures is a phenotypic character which can be modified adaptively in response to changed conditions during development, to a greater extent in outbred than in inbred individuals. In this particular case, therefore, the hypothesis outlined above has been confirmed.

The final paper was given by Dr. H. Rees on "The Stability of Meiosis in Inbred and Crossbred Rye". He said that when inbreeding is forced upon a species such as rye, which normally outbreeds, the progeny show inbreeding depression in relation to the chromosome mechanism much as they do for more familiar aspects of the phenotype. At meiosis one general consequence is a reduction in chiasma frequency. In some extreme cases when chromosomes are frequently unpaired and hence lost during cell division, this causes considerable pollen and egg infertility. Another result of inbreeding concerns the stability of plants in relation to chiasma frequencies. Thus *between plants* of identical genotype *within* inbred lines there is more variation in chiasma frequency than between plants of the same genotype within heterozygous families; under comparable experimental conditions the chiasma frequencies of homozygotes are less stable. Similarly, variation is greater between pollen mother cells within anthers of homozygotes than it is *within anthers* of heterozygotes. It has been found, however, that although homozygotes are generally less stable than heterozygotes, the instability cannot be explained in terms of the degree of homozygosis alone. Inbred lines equally homozygous may show different degrees of instability. Stability evidently must be related to the particular genotype.

Chiasma frequency, of course, to a large extent determines the degree of gene recombination and hence the variability in outbreeding populations. The average chiasma frequency is known to be genotypically controlled. The above results make it clear also that the range of chiasma frequencies within an anther (that is, the degree of 'instability') is also subject to the control of the genotype. From the population point of view this means, therefore, that the average amount of recombination through chiasma formation per plant may be adjusted by natural selection, and that the variety of the gametes, in respect of recombination, can also be adjusted adaptively.

J. M. Thoday

THE NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING, SHINFIELD

REPORT FOR 1955

SOME years ago Dr. E. V. McCollum, an eminent American authority on nutrition, stated that "The people who achieved, who have become large, strong, vigorous people, who have reduced their infant mortality, who have the best trades in the world, who have an appreciation for art, literature and music, who are progressive in science and in every activity of the human intellect, are the people who have used liberal amounts of milk and its products"! Even though this may well be regarded by many as something of an over-statement, it is undoubtedly true that milk contains a greater number of the individual nutrients essential for health in man than any other single food. Calculations made a few years ago showed that home-produced milk, consumed in Great Britain as liquid milk, supplied some 17 per cent of the total protein and some 12 per cent of the total fat in the people's food, as well as important proportions of its minerals, vitamins and energy content. The gross value of the milk and milk products produced annually in Britain amounts at present to some £400 million. Apart from economic considerations, it is worth recalling that the milk secretion process itself is one of the chief physiological functions on which the very existence of mammalian life depends.

With facts like these in mind, it is most encouraging to read of the work that is being done and the progress that is being made at the National Institute for Research in Dairying, Shinfield, under the direction of Prof. H. D. Kay, whose most informative annual report for 1955 has been recently published*. Lists of staff, patrons, fellows and members of the Institute are given, from which it can be seen that the number on the staff of the Institute now exceeds three hundred and that about a hundred of them are graduates in some branch of science.

The report can be regarded as consisting in the main of three principal parts. The first of these is the foreword, which contains a short but valuable outline of some of the recent findings that have been made at the Institute. More than thirty individual items are referred to. This part of the report should be of special interest to those who want to know as briefly as possible, and in an immediately practical way, what advances were made in 1955 without having to read in detail about the work of the Institute as a whole.

The second, and by far the largest, part of the report gives an account of each of the eight principal departments of the Institute, and also discusses the work of the four smaller sections that deal with such a wide variety of subjects as isotopes, statistics, psychology, and liaison with the dairy industry. Some of the problems under investigation are of a very practical nature, such as the prevention of infestation of cheese by mites, and the effect of 'vacuum' level on the rate of milking by machine. Others are scientifically more fundamental and require for their elucidation the expert knowledge and training of research workers in bacteriology, chemistry, physics, physiology, nutrition and engineering. Examples that might be cited of these fundamental researches are the work that is being done on the biochemistry and physiology of milk secretion with particular reference to the formation of fat and protein in the mammary gland, and the detailed study that is being made of the chemistry of the β-lactoglobulins in milk.

A third section of the report, which will prove of special value to many readers, comes under the heading of library. It gives a list, with full titles and references, of the 151 papers that were published by members of the staff between October 1954 and September 1955. A mere glance at this formidable list will impress the reader with the great scope and importance of the researches that are being done by what is clearly a very capable and enthusiastic band of workers.

* University of Reading. National Institute for Research in Dairying: Report 1955. Pp. 148. (Shinfield: National Institute for Research in Dairying, 1956.) 4s.

THE BRITISH STEEL CASTINGS RESEARCH ASSOCIATION

ANNUAL REPORT

THE British Steel Castings Research Association is one of the newest of the research associations operating under the aegis of the Department of Scientific and Industrial Research; although now having produced its third annual report*, this co-operative research organization, before it became attached to the Department, had been operating for some years under the wing of the British Steel Founders' Association. These were formative years, but from the present report it is apparent that this young and virile research body has reached a promising stage of development; and a new research station is in course of erection at a suitable site in Sheffield, the home of so many famous developments in the steel world.

The steel-founding industry in Britain would appear from this report to be a compact and co-operative industry, well able to uphold the best traditions of British engineering industry. Much of the work of the Association in its brief existence has been confined to work carried out in member foundries. This liaison would appear to be particularly good, advisory work being also done by the Association's staff. Further, extramural research has been supported at several universities, and work of considerable value has emerged from these activities.

In the early days of its existence, the parent body of the Association, known as the Research and Development Division of the British Steel Founders' Association, took over from the British Iron and Steel Research Association the work of the old Steel Castings Committee, which had been responsible for notable activities in the field of steel founding, in particular in regard to steel casting, moulding sand and furnace refractory practice. From the days of Boswell in the First World War, when the first scientific studies of British moulding sands were undertaken in a number of foundries, the steel-founding industry has applied progressively scientific methods to its moulding practice; the developments outlined represent, on the part of the steel-founding industry, the realization of the value of co-operative

* British Steel Castings Research Association. Third Annual Report, 1956. Pp. ii+26. (The Association, Broomgrove Lodge, Sheffield 10.)

scientific research. The work in the past has been closely associated with the Refractories Department of the University of Sheffield. From my own experience of the industry, this aspect of the work has already gained world-wide recognition, both in regard to the properties of the moulding materials available in Britain, and the bearing which founding techniques may have on the quality of the casting. The aim of the founder is to make a sound casting with the minimum of sand adherence, not only for the purpose of economical production in the foundry, but also with the object of reducing the health hazard in the foundry and the fettling shop.

The work of the Association is under the direction of Dr. A. H. Sully, and is divided into five main sections: (i) metallurgy, comprising in itself a field of wide scope, for man's mastery of the properties of metals is a never-ending pursuit; (ii) foundry practice and moulding materials; (iii) steelmaking; (iv) plant engineering; and (v) industrial health.

In the metallurgical field the immediate problems have been to study the practical techniques that produce sound castings and thereby the optimum mechanical properties, which the ever-increasing demands of engineering practice may require. This has involved the study of the interdendritic microporosity in steel castings, which may be of more widespread occurrence than is generally appreciated. An increasing need in engineering practice has been for materials that remain tough at very low temperatures. An investigation into such properties referred to in the present report has shown that for low- and medium-alloy steels the highest resistance at low temperatures is developed in fully hardened and tempered steels. The importance has also been demonstrated of avoiding temper brittleness in steels known to be susceptible to it by water quenching from the tempering temperature.

Considerable light has been thrown on the problem of sand adherence to steel castings by investigations carried out under Dr. T. P. Hoar at the University of Cambridge under the sponsorship of the Association. Equally interesting in these respects has been the research carried out under the supervision of Prof. J. White at the University of Sheffield on the hot-strength properties of moulding sands. Reaching the scale of extended and promising trials on the foundry floor is the use of sands bonded with bentonite–kaolinite clay mixtures that have been shown in the laboratory to have better foundry 'life' properties than mixes bonded solely with bentonites, the latter being generally an imported raw material.

In the steelmaking investigations, particular attention is being devoted to the use of oxygen injection, a relatively modern practice which promises to give enhanced control to the steelmaking process. Efforts are also being made to bring the conclusions of the many erudite studies of the physical chemistry of steelmaking on to the stage of the steel-melting furnace.

Plant engineering must ever be important in the growing mechanization and instrumentation in all types of industrial practice. In an industry in which the art of founding is applied, a complexity of process is inevitable, and therefore the engineering aspects introduce a wealth of needs. Improvements in fettling tools and moulding machines accordingly introduce problems that are to be found in the research programme.

Notable advances have been made in the field of industrial health. The Association has succeeded in introducing new methods of dust control in stand and swing-frame grinders, that have received the approval of H.M. Factory Inspectorate. One of the outstandingly successful events of the Association's year was the conference on "Steel Foundry Dust Control and Ventilation" held at York in October. The report of this conference has been adjudged by the practical observers of developments in the industry to have constituted a milestone of progress against the health hazards of the steel foundry, an achievement that must have valuable economic and social results.

The Association has a Technical Advisory Committee structure that is not too unwieldy, and yet brings to the Committee table the best brains in the industry, a commendable situation in these days when the efforts of too many executives and technical men tend to become strained in an almost committee-ridden age. In regard to the Library and Information Services, the policy has been continued of building up as complete a collection as possible of current literature on steel-foundry subjects, while relying on borrowing and interchange to fulfil marginal needs and other requirements. In these respects, Sheffield is building up an enviable reputation for the efficiency of its library and interchange services, so important a need in a great technological centre. The *Abstract Journal* of this Association can be regarded as one of the best of its kind. The new Research Station is expected to be completed before the end of the year.

R. J. Sarjant

COMPARISON OF SOME DIRECT AND INDIRECT EFFECTS OF IONIZING RADIATIONS IN PROTEIN

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A number of investigations[1] have shown that changes in chemical and physical properties of proteins occur after irradiation both in dilute aqueous solution, when the action is produced by the free radicals formed in the water, and in the solid state, when the energy is absorbed directly by the protein. We have studied with the same proteins both types of process to illustrate their similarities and differences. The relative efficiency of the two processes may provide a guide to their relative importance in initiating the series of processes which lead to cellular damage. The principal criteria used for determining alterations in the protein have been changes in solubility, ultra-violet absorption, chromatographic behaviour and alterations in molecular weight as revealed by light-scattering and the ultracentrifuge.

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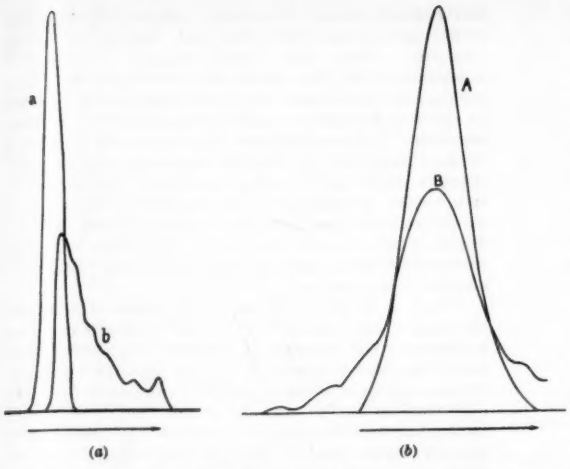

Fig. 1. The Lamm scale ultracentrifuge diagrams of irradiated bovine serum albumin

(*a*) Indirect effect. The control solution (*a*), and the irradiated solution (*b*) which has received 100,000 r., are 1 per cent.

(*b*) Direct effect. The solid has received 8×10^4 r. and is measured as a 1 per cent solution (*B*) compared with a control solution (*A*)

Indirect Effect

Dilute solutions of proteins are precipitated by irradiation with a sufficiently high dose; but little is known about the changes which precede this effect. Several workers[2,3] have reported on the apparent increase in the ultra-violet absorption and the formation of dimers upon the X-irradiation of serum albumin and fibrinogen, whereas hæmocyanin was shown by Svedberg and Brohult[4] to split into well-defined sub-units by α-irradiation.

We have found a marked rise in the weight average molecular weight of serum albumin (both human and bovine) as determined by light scattering upon exposure of dilute solutions to X-irradiation. This rise is due to the formation of a very polydisperse range of aggregates which have been shown by examination in the ultracentrifuge[5] (Fig. 1*a*) and the electron microscope to range from dimers up to units of many hundred molecules. Since the apparent molecular weight as measured by light scattering depended on the ionic strength of the solution in which the measurement was made, and furthermore could be reduced by the addition of urea (final strength 4 *M*) the larger aggregates behave as associations of partially denatured molecules held together by secondary forces. The proportion of protein in the main ultracentrifuge peak was unaltered by the addition of urea, so that it is probable that the smaller aggregates are covalently cross-linked.

We have confirmed the observation that the ultra-violet absorption of serum albumin at 280 mμ apparently increases after irradiation, but cannot accept the contention that this is the result of a preferential attack on the tyrosine residues which are responsible for this band[3]. The apparent increase is due to loss of light by the greatly increased scattering by the large aggregates formed on irradiation. The light scattering was measured directly at 436 and 546 mμ with an instrument used for molecular weight determinations, and the scattering at other wave-lengths was calculated by the Rayleigh–Debye equation. These values were used for correcting the spectrum determined in a spectrophotometer, when it is seen (Fig. 2) that the true absorption of the protein is only slightly, if at all, changed on irradiation. The correction applied for scattering may be somewhat too small, since the scattering was only determined for the angles between 40° to 135°, which will give a low value of the total loss of light due to the largest aggregates. For the experiment shown in Fig. 2, the weight-average molecular weight increased from 7×10^4 to $1{\cdot}5 \times 10^6$, while the number-average, estimated from the decrease in the amount of material with the sedimentation constant of the starting material, cannot have exceeded $1{\cdot}5 \times 10^5$. The great difference between these two averages proves that some very large aggregates must be present. If the serum albumin was irradiated in the presence of salt or titrated to a *p*H away from its isoelectric point, the change in the ultra-violet spectrum was less. This effect is not the result of protection by competition for the radicals formed by the salt, but is due to the fact that the aggregates formed are smaller and therefore scatter less light.

While the absorption of serum albumin at 280 mμ is almost wholly due to tyrosine, that of lysozyme at the same wave-length is due to tryptophan. On irradiation of dilute solutions of this enzyme with X-rays (see Fig. 3) the ultra-violet maximum first decreases, but increases again with larger doses. The initial effect probably represents a preferential attack on the tryptophan by the free radicals formed by irradiating water. This behaviour may be correlated with the ability of tryptophan and its derivatives to compete very effectively with other substances for free radicals produced in solution[6]. The increase at higher doses is again due to aggregation, and on correcting for this by measuring the scattered light, it appeared that the true absorption maximum continues to decrease.

The object of further research will be to determine the primary chemical changes, produced by the radiation, which result in the observed aggregation. This aggregation reflects a most significant physico-

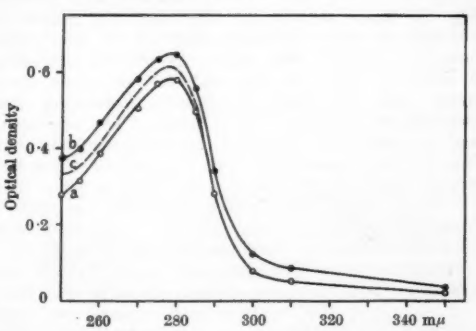

Fig. 2. Effect of irradiation on the ultra-violet spectrum of bovine serum albumin; 30,000 r. was delivered to a 0·1 per cent solution. The light scattering at 437 mμ and ultra-violet absorption was determined at 0·044 per cent in 0·1 *M* sodium chloride. The correction due solely to light scattering was calculated from the molecular weight, $1{\cdot}5 \times 10^6$ and the dissymmetry [~ 2]. (*a*) Control; (*b*) irradiated protein; (*c*) corrected curve

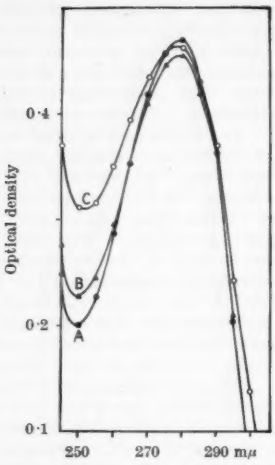

Fig. 3. Ultra-violet absorption spectrum of 0·025 per cent solutions of lysozyme (*B*) after 10,000 r., and (*C*) after 30,000 r., compared with an unirradiated control (*A*)

chemical change following an indirect action, and may also give rise to the other changes reported, such as more facile heat denaturation.

Direct Action

The irradiation of solid serum albumin produces effects which are quite different from those following indirect action. The protein was not dried completely, since it was felt that the presence of approximately 5 per cent of water, which is essential to retain the protein in its native form, would not introduce any significant 'indirect' contribution.

The radiation effect is influenced by the presence of oxygen; irradiation with γ-rays in air begins to render part of the sample insoluble in water at 4×10^5 r., and at 8×10^6 r. 90 per cent failed to pass through a filter of pore size less than 0·3μ after suspending in water. The fraction dissolving contains large aggregates, and these appear to behave in a similar way to those produced by indirect action; for example, a sample of bovine serum albumin given a dose of 2×10^6 r. has a weight-average molecular weight of $1{\cdot}5 \times 10^6$. The ultracentrifuge pattern (Fig. 1*b*) again shows that the irradiated protein is polydisperse and contains material of very high molecular weight. But unlike the protein irradiated in solution, some of this material sediments more slowly than the starting product, indicating that some degradation has taken place. The aggregate can, in part, be dispersed by concentrated urea. This will also dissolve some of the protein which had become insoluble in water with doses greater than 6×10^6 r. This behaviour suggests that secondary forces contribute to aggregation; but that new covalent inter-molecular cross-links are formed.

Irradiation of the dry material brings about a true change in ultra-violet absorption, as can be seen from Fig. 4, where the absorption measured has been corrected for scattering by the aggregates. This indicates that the tyrosine is attacked; the extent of the change is much greater than could be accounted for by energy taken up directly in the tyrosine residues themselves. The ultra-violet spectrum of polytyrosine (a sample kindly given by Dr. E. Katchalsky) is not detectably altered by the dose which produces a 20 per cent change in serum albumin. Since the initial uptake of energy is independent of the molecular structure, the same *fraction* of the tyrosine should be affected in a protein as in a polypeptide entirely composed of tyrosine residues. The observation that a greater proportion of the tyrosine is affected in the protein suggests that energy taken up in other amino-acid residues contributes to the attack on the tyrosine. This appears to be another example of a process found in other systems[7] also which we have referred to as energy transfer without implying any particular physical or chemical mechanism.

When a 1 per cent aqueous solution of serum albumin was irradiated with α-particles from polonium, the changes produced resembled those from the direct action of γ-rays, in that the ultra-violet absorption was generally increased and both aggregation and degradation were found. Since the biological effectiveness of α-rays is considerably greater than that of X-rays, we believe that the similarity of the effect of α-rays to direct action by sparsely ionizing radiation may be biologically significant.

Oxygen Effect

Barron and his colleagues[3] showed that the physico-chemical change produced by irradiation of serum albumin in solution was influenced by oxygen; but we were surprised when substantial differences were found between irradiations of the solid carried out in oxygen and in vacuum, since it was generally believed that oxygen effects occurred only when the action of the radiation was indirect. The first effect of irradiation is to produce aggregates, and with bigger doses true insolubility in water sets in. Both effects occur much more readily following irradiation in the presence of oxygen, and, for example, 8×10^6 r. in air renders 50 per cent insoluble while the same dose

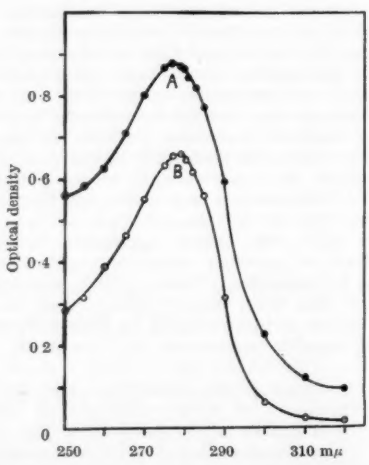

Fig. 4. Effect of irradiation on the ultra-violet absorption spectrum of solid serum albumin. The spectrum of a 0·1 per cent solution of material which has received 8×10^6 r. (in air) (*A*) is compared with that of an unirradiated control (*B*). The insoluble fraction (about 50 per cent) has been removed by a porous porcelain filter candle (max. pore diameter 0·5μ). Light-scattering measurements show that none of this increase is due to aggregation, since the weight-average molecular weight is less than 200,000

given *in vacuo* only produces aggregation which can be detected by light scattering and ultrafiltration.

Preliminary experiments showed that irradiation in oxygen introduces into serum albumin new groups (possibly unstable peroxides) which are capable of initiating the polymerization of vinyl compounds. For example, the addition of 20 mgm. of protein given 2×10^6 r. to 10 ml. of a 10 per cent aqueous solution of methacrylic acid, followed by removal of air from the solution, initiated immediate polymerization and the product appeared to be a 'graft' macromolecule containing protein and polymethacrylic acid. Unirradiated or vacuum-irradiated protein was ineffective for this purpose.

From ultracentrifuge measurements the amount of serum albumin having the sedimentation constant of the original material was determined after different irradiations. For indirect irradiation the rate of disappearance decreases with dose; but from the initial slope it can be computed[5] that one protein molecule becomes incorporated in an aggregate for every 250 eV. of energy deposited in the system (hence $G = 0{\cdot}4$). When the solid protein was irradiated, one molecule disappeared from the original peak in the ultracentrifuge pattern for every 50 eV. of energy taken up. Hence $G = 2{\cdot}0$ if oxygen is present, but the value is much less *in vacuo*. For this aggregation process direct action is approximately five times as efficient as indirect processes, and this shows, as has already been pointed out for the degradation of deoxyribonucleic acid[8], that the great preponderance of water in most living systems does not necessarily imply that the contribution of indirect action predominates in initiating the chain of events leading to the final injuries.

The ultracentrifuge measurements were made in the Institute for Physical Chemistry, Upsala, Sweden, and will be published jointly with Dr. Sven Brohult.

This investigation has been supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research: Royal Cancer Hospital), from the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

[1] See, for example, Errera, M. C. R., *Bull. Soc. Chim. Biol.*, **33**, 555 (1951). Bacq, Z. M., and Alexander, P., "Fundamentals of Radiobiology" (Butterworth, London, 1955).
[2] Fricke, H., *Cold Spring Harbor Symp. Quant. Biol.*, **6**, 164 (1938); *J. Phys. Chem.*, **56**, 789 (1952); *Nature*, **169**, 965 (1952).
[3] Barron, E. S., and Finkelstein, P., *Arch. Biochem. Biophys.*, **41**, 212 (1952). Carrol, W. R., Mitchell, E. R., and Callanan, M. T., *ibid.*, **39**, 232 (1952).
[4] Svedberg, T., and Brohult, G. S., *Nature*, **143**, 938 (1938).
[5] Brohult, S., and Rosen, D. (to be published).
[6] Alexander, P., Bacq, Z. M., Cousens, S. F., Fox, M., Herve, A., and Lazar, J., *Radiation Research*, **2**, 392 (1955).
[7] Alexander, P., and Charlesby, A., *Nature*, **173**, 578 (1954). Symp. Radiobiologie, 1954, p. 49 (Butterworth, London, 1955).
[8] Alexander, P., and Stacey, K. A., Brit. Empire Cancer Campaign, 1954. Progress in Radiobiology, 105 (Oliver and Boyd, 1956).

GENETICS OF HÆMOGLOBIN AND BLOOD POTASSIUM DIFFERENCES IN SHEEP

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IF hæmoglobin preparations from different adult sheep are subjected to electrophoresis on filter paper at *p*H 8·6, three distinct types of animal may be recognized[1]. One finds either a single component moving relatively rapidly towards the anode, or a single component moving rather more slowly, or a mixture apparently consisting of both these components. We will refer to the hæmoglobin moving more rapidly towards the anode at *p*H 8·6 as sheep hæmoglobin *A*, and to the less rapidly migrating hæmoglobin as sheep hæmoglobin *B*. The three types of animal can then be conveniently designated as *A*, *B* or *AB* with respect to their hæmoglobin constitution (Fig. 1).

Sheep may also be classified into two distinct types according to the potassium and sodium concentrations in their blood[2]. In one type the potassium concentration is relatively high (about 36 m.equiv./l.) and the sodium concentration correspondingly low, whereas in the other type the potassium concentration is relatively low (about 11 m.equiv./l.) and the sodium concentration correspondingly high. The two types of animal have been called *HK* and *LK*, respectively. The plasma potassium concentrations are the same in the two types of animal and the phenomenon is therefore entirely due to differences in the red blood cells. Preliminary evidence has indicated that these two types are genetically determined in a simple Mendelian manner, the *HK* type being recessive[3].

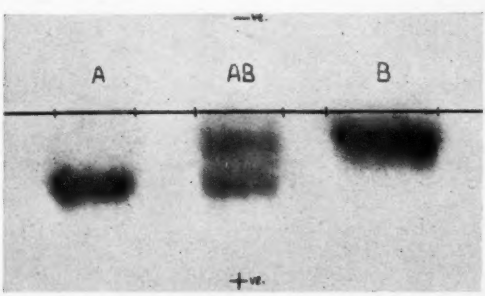

Fig. 1. Paper electrophoresis of the three types of sheep hæmoglobin
(0·15 *M* borate buffer, *p*H 8·6, 185 V., 17 hr.)

In the present investigation, the hæmoglobin and potassium types were determined on a large number of individual animals from a single flock in which detailed pedigrees were available. It was hoped to study among other things the genetics of the overall situation and to investigate any interrelationship between the two sets of red blood-cell characteristics.

A flock of Lanark-type Scottish Blackface sheep on rough hill grazing in Peebleshire was examined. The animals were bled at weaning time when the lambs were approximately six months old and the ewes varied from 2½ to 5½ years of age.

Table 1. Hæmoglobin and Potassium Types in 1,804 Scottish Blackface Sheep

	Hæmoglobin type			
	A	*AB*	*B*	Totals
High-potassium	577	314	46	937
Low-potassium	521	282	64	867
Totals	1,098	596	110	1,804

Table 1 shows the frequencies of the different phenotypes in 1,804 animals in which complete data were obtained. 61 per cent of the animals were of hæmoglobin type *A*, 33 per cent *AB*, and 6 per cent *B*. 52 per cent of the animals were *HK* and 48 per cent *LK*. There was no obvious association between any of the hæmoglobin types and either of the potassium types, and the two systems of classification appear to be independent.

Table 2 summarizes the family data in the hæmoglobin types. The table is incomplete with regard to certain of the mating types, because many of the rams used for producing the lamb crop had been sold before the hæmoglobin determinations were made. Nevertheless, a typical segregation pattern may be observed. *A* offspring are not produced if one or other parent is *B*, and *B* offspring are not produced if one or other parent is *A*. *A* × *A* matings produce only *A* offspring, whereas *AB* × *AB* matings produce all three types. The findings are consistent with the hypothesis that the hæmoglobin types are genetically determined by two alleles each responsible for the formation of one kind of hæmoglobin. On this hypothesis the gene frequencies can be obtained directly by counting, and in this population the

Table 2. Segregation of Hæmoglobin Types

Parents Ram	Ewe	Offspring *A*	*AB*	*B*	Total
A	× *A*	32	—	—	32
A	× *AB*	11	2	—	13
A	× *B*	—	1	—	1
AB	× *A*	25	23	—	48
AB	× *AB*	8	12	8	28
AB	× *B*	—	1	4	5
?	× *A*	200	64	—	264
?	× *AB*	61	66	14	141
?	× *B*	—	17	9	26
		337	186	35	558

Table 3. Hæmoglobin Types in 1,933 Animals. A Comparison of the Observed and Expected Proportions assuming a Hardy–Weinberg Equil'brium

Hæmoglobin type	Observed No.	Observed Per cent	Expected No.	Expected Per cent
A	1,173	60·7	1,155	59·8
AB	642	33·2	678	35·1
B	118	6·1	100	5·2
Totals	1,933		1,933	

Table 4. Segregation of Potassium Types

Parents Ram	Ewe	Offspring Observed *HK*	Observed *LK*	Expected *HK*	Expected *LK*
HK	× *HK*	106	2	105	—
HK	× *LK*	35	63	42	59
LK	× *HK*	39	39	35	46
LK	× *LK*	17	64	14	64
		197	168	196	169

frequency for the *A* hæmoglobin would be about 0·77 and that for the *B* hæmoglobin 0·23. Assuming random mating and no differential selection, one can calculate from the Hardy–Weinberg equation the expected proportion of the three phenotypes in the total population. Fairly good agreement is in fact obtained (Table 3). However, there is a slight deficiency of heterozygotes, the explanation of which is uncertain.

Table 4 summarizes the data on the inheritance of the *HK* and *LK* types. The expected numbers of segregants from the different matings have been calculated on the hypothesis that the dimorphism is due to a single gene pair, that *HK* is recessive and that mating is at random. The observed and expected numbers are in good agreement. The only notable discrepancy is the occurrence of two *LK* animals from matings of *HK* parents, and these can probably be attributed to mistaken identity or illegitimacy. The *HK* animals can therefore be regarded as homozygous for one allele whereas the *LK* animals represent the heterozygotes and also the homozygotes for the other allele. The possibility that the gene responsible for the *LK* phenotype may not be completely dominant has been examined by comparing the quantitative findings in known heterozygotes with those obtained in the remainder of the *LK* animals. A significant difference of 0·68 m.equiv./l. whole blood was observed, the heterozygote having the higher value. This would imply an average difference between heterozygous and homozygous *LK* animals of about 1·7 m.equiv./l.

The absence of association between the hæmoglobin phenotypes and the potassium phenotypes presumably means that the genes responsible for the two sets of red cell characteristics are at independent loci. Nevertheless, in both high- and low-potassium phenotypes, individuals with hæmoglobin *A* have higher average values of whole-blood potassium than those with hæmoglobin *B*, whereas the *AB* individuals are intermediate.

Table 5. Mean Concentrations of Whole-blood Potassium in each Phenotype

Hæmoglobin type	Potassium type *HK*	Potassium type *LK*
A	38·8 ± 0·2	12·0 ± 0·1
AB	36·4 ± 0·2	11·3 ± 0·1
B	34·8 ± 0·6	10·6 ± 0·2

Data on the concentration of red blood-cell potassium in the different hæmoglobin types will obviously be required before the physiological significance of this correlation can be assessed.

One of us (F. L. W.) is in receipt of a grant from the Agricultural Research Council.

[1] Harris, H., and Warren, F. L., *Biochem. J.*, **60**, xxix (1955).
[2] Evans, J. V., *Nature*, **174**, 931 (1954).
[3] Evans, J. V., and King, J. W. B., *Nature*, **176**, 171 (1955).

NATURE OF THE TUMOUR-ENHANCING FACTOR

By Prof. H. N. GREEN and R. WILSON

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INTEREST in the nature and mechanism of the enhancing factors present in tumour and normal tissues has increased latterly, though first described by Flexner and Jobling[1] so long ago as 1907. We have recently reviewed[2], *inter alia*, the literature of the enhancing factors which break down homologous and even heterologous host resistance to transplanted tumours and have worked with them for several years, realizing that they provide an important clue to the nature of certain tissue antigens concerned both in tumour immunology and in transplantation surgery.

The rat sarcoma (*Rd*/3) used was responsive to the enhancing factor in lyophilized *Rd*/3 sarcoma[3]; and from experiments using cortisone in normal and adrenalectomized rats, it was suggested that the enhancing factor effect was the indirect result of a heightened immunity, which was of a different order to immunity to living tumour cells for it occasioned no plasma cell response, nor increase in size of the lymph nodes or spleen. The work of Kaliss[4] showing that combined pre-treatment with cortisone and enhancing factor weakened or abolished the enhancing effect was confirmed in rats[5], as was that of Kaliss and Molomut[6], who showed that enhancing factor activity was present in rabbit and mice antisera to mixed mouse tissue antigens.

All results, including the appearance of rat-cell hæmolysins in the serum, pointed to the apparent paradox that enhancing factor treatment was a process of active immunization. Since tumour immunity was abolished thereby, lethal tumour antibodies were not being induced, and a working hypothesis was the formation of an incomplete or blocking antibody. This accorded with the fact that enhancing factor activity was not found in extracts of completely normal tissues, but only in those damaged by heating, freezing, mechanical disintegration, etc. (see Green[2]). A search was begun for the responsible tumour antigen(s) and by that time much serological work on tumour-bearing animals suggested that tumour lipids and lipoproteins might be incriminated, particularly as it was already known that enhancing factor activity was present both in fatty and watery tissue extracts. Work was in progress (Hakim and Green[7]) suggesting, *inter alia*, that the spontaneous tumour after transplantation might contain new phospholipids. (The work is still incomplete, but Hakim[8] has published a short account of some of it.) A phospholipid extract from *Rd*/3 sarcoma was thus available and it was injected into a strain of Wistar rats (Leeds) which at that time was resistant to growth of this tumour. In the first experiment thirty-four of thirty-six treated rats grew lethal tumours and only one of ten controls. A second experiment was nearly as decisive. The lipid was effective in doses of 4–0·4 mgm. when mixed with the tumour inoculum or given intraperitoneally. As it transpired, these were lucky results, such small doses being effective probably because only very slight lowering of immunity was needed to break down strain resistance. In succeeding experiments the tumour was rapidly adapting itself to the host. This factor was not then realized, and failure to obtain enhancement with later lipid fractions led us to numerous modifications in extraction methods without success, for neither tumour phospholipid nor lipoprotein was regularly enhancing in pre-treated rats, but more often immunizing. Employing much higher doses, however, the last three experiments were even more decisive than the first, and it is now certain that the enhancing factor activity resides mainly, if not wholly, in the tumour lipoproteins and that the phospholipids, when artificially separated, retain much of this activity.

Table 1. Enhancing Effect of Fractions from Frozen *Rd*/3 Sarcoma

Average figures of groups of five rats injected during ten days prior to tumour transplant

Tumour preparation	Dose	Tumour area 13 days (sq. cm.)	Tumour wt./100 gm. carcass 16 days (gm.)	Spleen wt./100 gm. carcass 16 days (mgm.)
Saline emulsion of frozen tumour	0·5 ml.	2·1	19·9	287
50 per cent soluble protein	3 × 1 ml.	2·0	19·3	377
50 per cent soluble protein (petrol. ether extracted)	3 × 1 ml.	1·9	21·4	310
Lipoprotein*	3×10 mgm.	2·2	20·6	363
Crude phospholipid*	3×25 mgm.	1·9	20·2	413
Nil	—	1·2	8·6	721

All given intraperitoneally except Group 1 which was subcutaneous.

* Enhancement now maintained for 4 generations without further treatment.

Table 2. Enhancing Effect of Fractions from Fresh *Rd*/3 Sarcoma

Average figures of groups of seven rats injected over ten days prior to tumour transplant

Tumour preparation	Dose	Route	Tumour wt./100 gm. carcass at 14 days (gm.)	Spleen wt./100 gm. carcass at 14 days (mgm.)
50 per cent soluble protein	5 × 1 ml.	Intraperitoneal	17·6	466
50 per cent soluble protein (petrol. ether extracted)	5 × 1 ml.	,,	16·7	425
Soluble protein (lipoprotein extracted)	5 × 1 ml.	,,	9·4	590
Lipoprotein*	2×17 mgm.	Intravenous	19·8	401
Phospholipid*	2×50 mgm.	,,	16·5	408
Controls	—	—	8·1	680

* Enhancement now maintained for 4 generations without further treatment.

Results of two experiments are given in Tables 1 and 2. In one the tumour was stored at 0° C. for fourteen days, whereas in the other fresh tissue was used. The extracts were prepared as follows:

Soluble protein: Sarcoma homogenized in blender in normal saline to yield a 50 per cent (wet weight)

solution. Stood 30 min. (0–5° C.), centrifuged at 4,000 rev./min. for 2 hr. Supernatant solution used.

Lipoprotein: Cold ethanol added slowly with stirring to equal volume soluble protein extract. Stood 12 hr. (0–5° C.), centrifuged and supernatant dialysed 24 hr. against 0·1 *M* saline using 'Visking' dialysis tubing. Lipoprotein freeze-dried.

Soluble protein after lipoprotein extraction: Alcohol precipitate redissolved in normal saline to yield 50 per cent (equiv.) solution.

Crude phospholipid: Sarcoma homogenized with 10 vol. cold 95 per cent ethanol–ether (3 : 1) for 15 min. Stood 30 min. Centrifuged to clarify. Supernatant concentrated to a few millilitres by vacuum distillation under nitrogen at room temperature. Residue extracted with three volumes of chloroform repeated thrice. Chloroform extract washed overnight in cold room with distilled water, and vacuum-distilled under nitrogen at room temperature.

Refined phospholipid: Crude phospholipid dissolved in petroleum ether (40–60° C.), centrifuged and any sediment discarded, precipitated with excess of acetone and a few drops of a cold saturated solution of magnesium chloride in ethanol.

The results were unequivocal and show that in both frozen or fresh tumour homogenate the enhancing factor is associated with a tumour lipoprotein fraction, little activity remaining after its removal, whereas the lipid-extracted soluble proteins retained full activity. Enhancing activity was greater in material from frozen tumours, and it should be noted that a simple unhomogenized suspension of frozen tumour was rich in enhancing factor. Tumour phospholipids were also active though not quite so much as the lipoprotein. In one experiment (Table 2) additional groups (not tabulated) were given serum and serum gamma-globulin from sarcoma-bearing and normal rats, and splenic soluble proteins from tumour-bearing rats. In all groups there was slight but definite enhancement, the greatest being with gamma-globulin from tumour-bearing rats, thus confirming the result of Kaliss and Kandutsch[9] in mice.

A striking feature was the size of the spleen, which normally progressively increases during growth of this tumour. There was an inverse relationship between splenic size and the enhancing activity of the extracts (cf. Tables 1 and 2) which has been evident in all successful experiments. Enhancement abolishes the normal immune reaction of the host to the tumour.

From these results and many others, the chemical nature of enhancing factor is now clear and its mode of action fairly clear. It is a lipoprotein, and the lipid haptene, which is also enhancing, is a phospholipid(s). The former is the water-soluble enhancing factor and the latter the fat-solvent-soluble enhancing factor. The chemical nature of the active phospholipid(s) is still not certain, though work in progress with Mr. J. W. Westrop should soon be conclusive for at least one tumour. The indications are that it may vary with type of tumour and with the species.

It seems that on injection it is capable of binding with protein and becoming antigenic lipoprotein. From the results of diverse immunization methods, it is clear that both tumour lipoprotein and phospholipid are antigenic in the rat, mouse and rabbit and elicit lipoprotein antibodies. Such serum antibodies have themselves some enhancing action, so that the enhancing factor effect cannot be due to fixation of tumour antibody by the excess antigen injected.

How do such antibodies in sufficient quantity abolish the normal immune response to the tumour? One of us (H. N. G.) has adopted throughout this work the hypothesis that they are blocking antibodies which render the tumour antigens inert. Our results support this; but Billingham *et al.*[10] have suggested that nucleoprotein antigens are destroyed by a mild injury which leaves the cytoplasmic antigens intact, and that antibodies to the latter inactivate the nuclear antigens emerging from the graft. Our findings also accord with this hypothesis, for the lipoproteins do elicit serum antibodies, including hæmagglutinins. Our hypothesis differs in envisaging neutralization of lipoprotein antigens in the cell membrane with possibly, though not necessarily, blocking of normal antibody. This does not easily account for the restoration of immunity in the animal treated with enhancing factor by grafting of immune lymph nodes and the fact, which we have repeatedly observed, that no enhancement is possible in the actively immunized rat (that is, after regression of a tumour). In the first case, however, normal antibody may be at such a high level when the tumour inoculum is given that it over-rides any blocking effect of incomplete antibody. In the second case, it is also likely that the injection of a slightly modified antigen would stimulate the production, already in progress, of normal antibodies. However, the fact that serum gamma-globulin from tumour-bearing rats has some enhancing action suggests that normal lipoprotein antibody is involved. The facts best fit the hypothesis of Billingham *et al.*[10], though it must be emphasized that the lipoprotein antigens are also very unstable and that antibodies to them might not unite with a pure nucleoprotein—a lipo-nucleoprotein complex in the nucleus might, however, be envisaged.

The importance of the present results, however, is their bearing on the homologous grafting of normal tissues. The facts undoubtedly apply here in some degree, for the iso-antigen(s) of tumour cells differs only quantitatively from the normal. The results of many attempts to produce tolerance to skin and other tissue grafts with normal phospholipids and lipoproteins have been erratic; but recent results are encouraging. The ultimate possibility of producing tolerance to normal tissue homografts, and even heterografts, by pre-treatment with specific lipoproteins will, when realized, profoundly affect the scope of surgery. The experiments reported here and related ones, together with their bearing on the immunological theory[2,12] of cancer, will be presented in detail later.

[1] Flexner, S., and Jobling, J. W., *Proc. Soc. Exp. Biol. Med.*, **4**, 156 (1907).

[2] Green, H. N., "Cancer", **2**, edit. R. W. Raven (Butterworth, London, 1956) (in the press).

[3] Green, H. N., *Brit. Emp. Cancer Campaign Annual Report*, **31**, 212 (1953).

[4] Kaliss, N., *Ann. N.Y. Acad. Sci.*, **59**, 385 (1955).

[5] Green, H. N., *Brit. Emp. Cancer Campaign Annual Report*, **54**, 228 (1954).

[6] Kaliss, N., and Molomut, N., *Cancer Res.*, **12**, 110 (1952).

[7] Hakim, A. A., and Green, H. N., communication to the Northern Cancer Research Workers' Conference, Birmingham, September (1955).

[8] Hakim, A. A., *Proc. Amer. Assoc. Cancer Res.*, **2**, 113 (1956).

[9] Kaliss, N., and Kandutsch, A. A., *Proc. Soc. Exp. Biol. Med.*, **91**, 118 (1956).

[10] Billingham, R. E., Brent, L., and Medawar, P. B., *Transplant Bull.*, **3**, 84 (1956).

[11] Mitchison, N. A., *J. Exp. Med.*, **102**, 157 (1955).

[12] Green, H. N., *Brit. Med. J.*, ii, 1374 (1954).

DIURNAL RHYTHMS IN SEMEN YIELDS AND MATING BEHAVIOUR IN THE DOMESTIC COCK

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WELLS[1] has suggested that much avian behaviour may be based on inherent rhythms. The mating activity of the domestic cock shows a marked diurnal rhythm[2–5], in that the majority of matings occur in the late afternoon. Riley[5] and Macartney[6] found that mitotic activity in the cock's testis was greatest during the night, thus suggesting that the production of spermatozoa may not be uniform during the day. The object of this work is to investigate the relationship between semen yields and mating activity in the Brown Leghorn cock.

Twelve cocks selected on their ability to produce adequate semen samples were used as semen donors. They were kept in individual cages where they had access to mash and water at all times, and in the late afternoon they were given grain. They were divided into three groups of four, and semen was collected on three days—May 30, June 4 and June 9—during the periods 08.30–09.30, 12.00–13.00 and 17.00–18.00 hr. Each group was tested at a different time on subsequent days of collection. This procedure was followed as it was considered, from previous experience, that over the short period of the experiment there would be no systematic changes in semen yields. Semen was collected by lumbar massage three times during the hours stipulated above, and the total volume and total absolute number of spermatozoa yielded were assessed for each cock.

To estimate the number of spermatozoa, a Spekker photo-electric fluorimeter was used as a turbidimeter, with a 1 in 500 dilution of semen and neutral filters (*H*508). The instrument had been calibrated previously against counts of spermatozoa made with a haemocytometer. The diluting fluid was a 1·025 per cent solution of sodium chloride containing 1 per cent formalin.

Two cocks of the same age and breed as the donors were used for observations on mating frequencies. They were each resident in a pen with laying hens and were each observed on two days between May 30 and June 10 during the hours of semen collection. In their pens they had free access to mash and water and were given grain at the same time as the donors.

The volumes of the semen yields for each cock are shown in Table 1. A two-way analysis of variance

Table 1. VOLUME OF SEMEN YIELDS (MEASURED IN ML.) COLLECTED FROM EACH COCK

Cocks	Times of collection		
	08.30–09.30	12.00–13.00	17.00–18.00
1	0·82	0·48	0·86
2	0·20	0·16	0·47
3	0·48	0·40	0·70
4	0·36	0·30	0·72
5	0·62	0·63	0·71
6	0·14	0·12	0·19
7	0·50	0·01	0·52
8	0·58	0·48	0·46
9	0·28	0·30	0·33
10	0·63	0·77	0·90
11	0·18	0·22	0·51
12	Nil	0·40	0·29

Table 2. TOTAL ABSOLUTE NUMBER OF SPERMATOZOA YIELDED BY EACH COCK

Cocks	Times of collection		
	08.30–09.30	12.00–13.00	17.00–18.00
1	$6·333 \times 10^9$	$3·302 \times 10^9$	$5·798 \times 10^9$
2	1·278	1·16	2·156
3	3·487	3·478	4·473
4	2·991	2·841	6·724
5	3·014	3·255	3·428
6	0·804	0·503	0·938
7	3·208	Nil	2·637
8	3·277	2·674	2·739
9	1·657	1·675	1·705
10	5·068	5·876	7·388
11	1·000	0·900	2·385
12	Nil	2·390	1·538

on these data showed that the differences between cocks were significant ($P<0·01$) and that the differences between yields at the various times of collection were also significant ($P<0·01$). The greatest yields were found to occur in the late afternoon.

The total absolute number of spermatozoa yielded by these cocks was also found to vary significantly between cocks ($P<0·01$) and between times of collection ($P<0·05$) when the data were analysed by means of a two-way analysis of variance. As with volume, the absolute number of spermatozoa was found to be greatest in the late afternoon (Table 2).

Nineteen matings were performed by the control cocks during the hours of observation, and of these thirteen occurred between 17.00–18.00 hours, thus showing that mating activity is high when semen yields are at their best. These results differ from those reported by Parker, McKenzie and Kempster[3]. These workers used a semen collector attached to the cloaca of the cock, which intercepted emissions from cloaca during natural matings and in the periods between matings. They reported that semen volume was greatest in the morning and that the total number of spermatozoa yielded did not differ significantly between morning and afternoon. Attempts to use a semen collector of this type on the cocks at this laboratory have been repeatedly unsuccessful due to contamination with urine and fluids from the cloacal glands, and in this study only direct reflex emissions from the ejaculatory ducts were taken to represent fowl semen, so as to avoid contamination with cloacal fluids and urine. This difference in technique may explain the variance between these results and those of Parker *et al.* (*loc. cit.*).

The relationship between semen yields and mating activity is under further investigation and will be reported elsewhere.

[1] Wells, G. P., "The Sources of Animal Behaviour" (H. K. Lewis and Co., Ltd., London, 1955).
[2] Upp, C. W., *Poult. Sci.*, **7**, 225 (1928).
[3] Parker, J. E., McKenzie, F. F., and Kempster, H. L., *Poult. Sci.*, **19**, 191 (1940).
[4] Long, E., and Godfrey, G. F., *Poult. Sci.*, **31**, 665 (1952).
[5] Riley, G. M., *Poult. Sci.*, **19**, 360 (1940).
[6] Macartney, E. L., *Poult. Sci.*, **21**, 130 (1942).

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Increase in γ-Radiation from Powdered Milk and Beef, 1953-56

Two apparatuses consisting of cylindrically arranged high-pressure ion chambers (diameter of sample container approximately 1 m., total volume approximately 3 m.³, 20 kgm. nitrogen and carbon dioxide) placed in a low-background laboratory in the rock near the city of Stockholm, and protected in all directions by 1 m. of water and more than 50 m. of granite, have been described in earlier communications[1]. In these, the results of measurements on 306 persons who have had no known contact with other than natural radioactive material of common concentration were also reported. The γ-radiation of human subjects is, in all probability, caused mainly by the potassium-40 content of the body, as has been shown by Burch and Spiers[2].

The same instruments have now (May–July 1956) been used for determination of the possible amount of γ-radiating fission products in powdered milk and beef preserved during the years 1953–56. The potassium content of the powdered milk was carefully determined by the Institute of Radiophysics and the Department of Clinical Biochemistry at Karolinska Sjukhuset, entirely independently. The absorption of the radiation from potassium-40 and cæsium-137 was measured by mixing 500 gm. of potassium chloride and 0·1 μc. of cæsium-137, respectively, in the milk samples, each of which weighed 10 kgm.

Table 1

Body weight (kgm.)	<25 F	25·1–35·0 M	25·1–35·0 F	35·1–45·0 M	35·1–45·0 F	45·1–55·0 M	45·1–55·0 F
1954							
Number of subjects	6	18	18	20	17	10	12
Average weight (*a*)	22·2	30·0	30·4	40·4	40·6	49·5	49·6
Average age	8·1	9·4	9·1	12·2	11·9	13·3	13·7
γ rad. (min.)	2·23	2·80	2·05	2·94	1·99	4·41	3·39
(in ng.) (max.)	4·12	4·95	4·45	6·62	6·45	7·32	7·18
Radium eq. average (*b*)	3·12	3·74	3·35	4·87	4·22	5·81	5·22
10 *b*/*a*	1·41	1·25	1·10	1·21	1·04	1·17	1·05
Standard error	0·077	0·057	0·050	0·052	0·072	0·050	0·045
1956							
Number of subjects	2	13	16	27	10	5	6
Average weight (*a*)	21·5	31·2	31·6	40·3	39·7	50·8	47·5
Average age	10·0	10·5	10·4	12·3	12·6	13·2	13·3
γ rad (min.)	2·57	2·70	2·20	2·69	3·03	5·68	3·66
(in ng.) (max.)	2·63	5·35	5·17	6·39	7·01	6·25	6·45
Radium eq. average (*b*)	2·60	4·10	3·67	4·55	4·47	6·09	4·50
10 *b*/*a*	1·21	1·31	1·16	1·13	1·13	1·20	0·95
Standard error	0·014	0·083	0·067	0·042	0·091	0·024	0·053

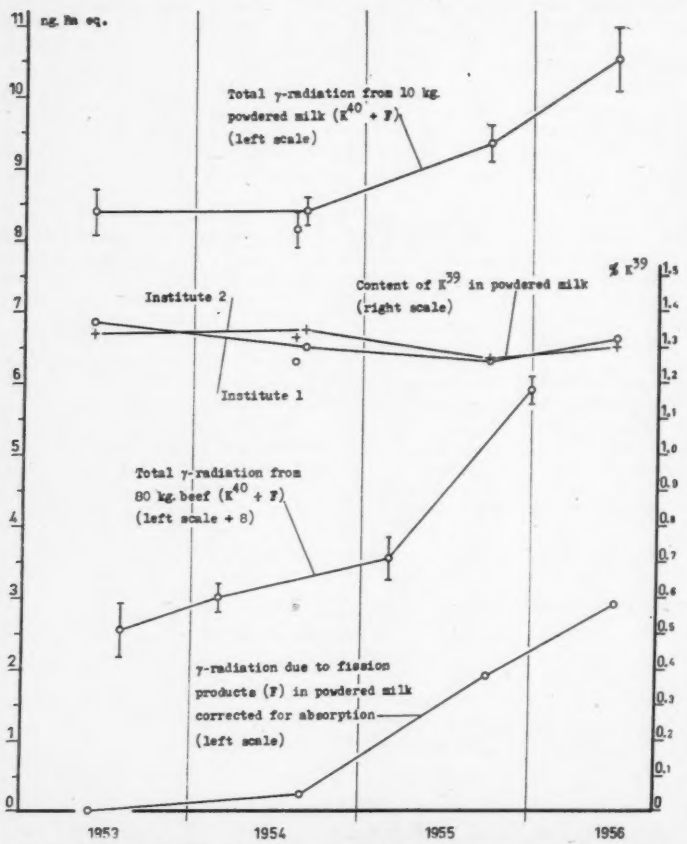
ng Ra eq.
Total γ-radiation from 10 kg. powdered milk (K^{40} + F) (left scale)
% K^{39}
Content of K^{39} in powdered milk (right scale)
Institute 2
Institute 1
Total γ-radiation from 80 kg. beef (K^{40} + F) (left scale ÷ 8)
γ-radiation due to fission products (F) in powdered milk corrected for absorption (left scale)
1953
1954
1955
1956

Fig. 1. Radiation from powdered milk and from beef. The observations on powdered milk were all carried out during the period May 18–July 3, 1956, and those on beef during the period July 1–9, 1956. Standard errors are indicated in respect of the observed radiation values

The results of these measurements are plotted in Fig. 1. An increased γ-radiation is obvious, which cannot have been caused by differences in the potassium content. If this increase is due entirely to cæsium-137, the concentration in the natural milk for the samples from 1956 can be calculated to be about 1×10^{-4} μc. per litre of milk, that is, 5×10^{-8} of the maximum permissible concentration. Because of the comparatively small age of the last samples it seems, however, likely that other fission products may have played the predominant part.

Beef from the years 1953–55 was also examined, each sample consisting of 80 kgm. of meat. The results are also shown in Fig. 1. Since the potassium content is probably the same in all these samples, the higher γ-radiation found in the last year here may also be attributable to an increase in fission products.

Although the quantities observed would probably be too small to cause a detectable increase in the γ-radiation from human subjects consuming milk, a series of children were investigated, and the results compared with the earlier measurements referred to at the be-

ginning of this communication. As seen from Table 1, the two sets of observations (1954 and 1956) are well suited for such a comparison. No significant change could be detected, however, in the average γ-radiation.

The investigation is being continued.

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[1] Sievert, R. M., "Peaceful Uses of Atomic Energy", **13**, 187 (1955); *Strahlentherapie*, **99**, 185 (1956). Sievert, R. M., and Hultqvist, B. (to be published).
[2] Burch, P. R. J., and Spiers, F. W., *Nature*, **172**, 519 (1953).

The Serum Gamma-Globulin-Level in Malignant Disease

Very little is known about immunity in relation to malignant disease. In animals there is evidence that resistance develops to transplanted tumours. Lumsden[1] and his co-workers were of the opinion that this resistance was due to the appearance in the serum of certain antibodies. They found that the serum of rats bearing the Jensen rat sarcoma contains a cytotoxin which is greatest in amount in those rats in which tumour regression afterwards occurs. In the human subject the development of humoral resistance to malignant tumours has not been proved conclusively. A number of workers have investigated the serum gamma-globulin-level in patients with malignant disease. Their results can be taken as a measure of the antibody-level since most antibodies are found in association with the gamma-globulin fraction of the serum protein. Petermann and Hogness[2] found that the serum gamma-globulin-level, as estimated by electrophoresis at *p*H 8·6, was normal in twenty-five patients with carcinoma of the stomach. Miller and Erf[3], using a similar method, found that the serum gamma-globulin was raised in twenty-four patients with carcinoma of the gastro-intestinal tract or breast.

In view of the difference between these results it was decided to perform further electrophoretic investigations on the serum gamma-globulin-level of patients with malignant disease. It was hoped by this means to determine with some degree of certainty whether the antibody-level of the serum changes in the presence of malignant neoplasms.

Twenty-two female patients from the Dartford Group of Hospitals, Kent, suffering from malignant disease, which had been verified by histological examination, were used for the present investigation. The patients were chosen at random and their ages varied from thirty-one to seventy years. The majority of the tumours were situated in the genital or intestinal tracts and were at different stages of development, some being localized while others had metastasized widely. Blood samples were taken from each patient on admission, and only the blood from those patients having normal temperatures, total and differential leucocyte counts, erythrocyte counts and hæmoglobin-levels were used. Blood samples were also taken from twenty healthy females of the same age-group to serve as controls.

The gamma-globulin-level of each of the sera was estimated by first separating the gamma-globulin fraction by paper electrophoresis at *p*H 8·5 using a veronal buffer. The filter-paper strips were then treated with bromphenol blue and the optical density of the protein dye complex was measured by means of a photoelectric cell. In this manner the percentage of gamma-globulin in relation to the total protein in the serum could be assessed.

No significant difference was found between the serum gamma-globulin-levels of the patients with malignant disease and those of the healthy controls. The gamma-globulin-level in each group averaged approximately 20 per cent of the total serum protein. These findings provide further evidence that the development of malignant disease in man is not associated with an increase in the antibody-level of the serum.

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[1] Lumsden, T., and Phelps, H. J., *Amer. J. Cancer*, **29**, 517 (1937).
[2] Petermann, M. L., and Hogness, K. R., *Cancer*, **1**, 100 (1948).
[3] Miller, B. J., and Erf, L., *Surg. Gynaec. and Obst.*, **102**, 487 (1956)

The Expected Blood-Group Antibody, anti-Lu^b

The Lutheran blood group system was first described by Callender and Race[1] in 1946: an antibody, afterwards named anti-Lu^a, was found to react with the red cells of approximately 8 per cent of the English population. The antigen with which the antibody reacts is called Lu^a and can be recognized in the red cells of heterozygous as well as homozygous individuals. The corresponding gene is called *Lu^a* and an allele *Lu^b* is postulated. The antigen Lu^b has been recognizable so far only as an absence of Lu^a; thus persons of the phenotype Lu(a−) are presumed to be of the genotype *Lu^{b}Lu^b*.

The results of testing large numbers of English blood samples with various anti-Lu^a sera have been brought together by Race and Sanger[2], and the following gene and genotype frequencies for the Lutheran system have been calculated.

Genes		Genotypes	
Lu^a	0·0390	*Lu^{a}Lu^a*	0·0015
		Lu^{a}Lu^b	0·0750
Lu^b	0·9610	*Lu^{b}Lu^b*	0·9235

An antibody which gives the reactions expected of anti-Lu^b has now been found in the serum of a woman, Mrs. R., who has never been transfused and who has given birth to three healthy children.

In a search for compatible blood for Mrs. R. it was found that her serum agglutinated saline suspensions of the red cells of each of fifteen blood samples. The identity of the antibody was suspected when it was found that Mrs. R.'s own cells reacted very strongly with an anti-Lu^a serum and that her serum reacted less well with Lu(a+) cells than with Lu(a−) cells.

Mrs. R.'s phenotype is as follows: O, MNSs, P+, CcDEe, Lu(a+), K+ k+, Le(a− b+), Fy(a−), Jk(a+ b+). The cells react with an anti-H serum. Dr. R. R. Race kindly tested the cells with anti-U, anti-Vel, anti-Yt^a and anti-Tj^a; in each case a positive reaction was obtained.

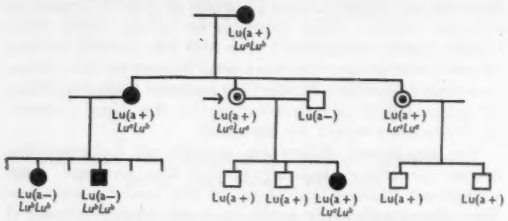

Fig. 1. The Lutheran groups and presumed genotypes of the family of the donor of anti-Lu^b. Arrow, donor; black, Lu(b+); dot, Lu(b−); blank, not tested with anti-Lu^b because of ABO incompatibility

The following findings support the hypothesis that Mrs. R. is of the rare genotype *Lu^{a}Lu^a* and that her serum contains anti-Lu^b.

(1) Five Lu(a+) and sixteen Lu(a−) blood samples from adults of group O were tested against dilutions of Mrs. R.'s serum. The average titration score for the Lu(a+) samples was 16 (range 12–13); that for the Lu(a−) samples was 28 (range 20–38). The agglutination reactions were 'scored' as suggested by Callender and Race[1].

(2) Mrs. R.'s serum reacted with all of 532 unselected samples from adults of group O. From 322 of these, 64 samples which reacted weakly were selected for testing with an anti-Lu^a serum: 17 (26·56 per cent) were Lu(a+). It can be calculated that on a sample of 64, the standard error of the expected percentage (7·65) of Lu(a+) bloods is 3·3. Thus the deviation from the expected percentage is five times the standard error.

(3) Fifty blood samples known to be of the phenotype Lu(a+) were tested; one of these (from Mrs. L.) failed to react with Mrs. R.'s serum. Mrs. L.'s serum does not react with Lu(a−) cells.

(4) The blood groups of a number of Mrs. R.'s relatives were determined. Their reactions with anti-Lu^a and with Mrs. R.'s serum are shown in the pedigree (Fig. 1). One sister is of the presumed genotype *Lu^{a}Lu^a*, since her cells react with anti-Lu^a but fail to react with Mrs. R.'s serum; her serum does not react with Lu(a−) cells.

Mrs. R.'s cells give a higher titration score with an anti-Lu^a serum than do the cells of her mother or those of her children.

(5) Callender and Race[1] described a family (Family 5) in which both parents and all four children were Lu(a+). As there seemed a good chance of finding a homozygote among the children, the family has been tested again: one of the children fails to react with Mrs. R.'s serum and is presumably of the genotype *Lu^{a}Lu^a*. The cells of both parents react with Mrs. R.'s serum.

The antibody in Mrs. R.'s serum reacts strongly at 20° C. and less well at 37° C., as a saline agglutinin. The agglutinates are firm; but many free cells are present. The reaction is not inhibited by the saliva of secretors or non-secretors. At 37° C. the antibody gives a weak indirect anti-human globulin reaction, but only with Lu(a−) cells. Following the intravenous injection of 1 ml. of Lu(a−) red cells the antibody increased in avidity.

We should like to thank Dr. P. L. Mollison and Dr. R. R. Race for their help during this investigation, and Dr. Gertrude Plaut and Dr. T. E. Cleghorn for supplying large numbers of blood samples. Dr. A. Davis and Dr. R. J. Drummond kindly obtained blood samples from Mrs. R.'s family and from Family 5.

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[1] Callender, Sheila T., and Race, R. R., *Ann. Eugen.*, **13**, 102 (1946).
[2] Race, R. R., and Sanger, Ruth, "Blood Groups in Man", 2nd edit. (Blackwell Scientific Publications, Oxford, 1954).

Two Stages in the Formation of Active Plasma Thromboplastin

Although the exact role of calcium in the complex mechanism of blood coagulation is still in some dispute, it is certain that it is a basic element in some of the interactions taking place between the various blood-clotting factors which finally lead to the formation of the prothrombin-converting factor, plasma thromboplastin[1]. Recently, we[2] described an ether-precipitation method for the separation of the latter. Further work, reported herein, on the relation between this important blood-clotting factor and calcium has revealed the presence of two stages in the production of a fully active plasma thromboplastin.

A study on the effect of calcium chloride, calcium gluconate, calcium lactate, strontium chloride and magnesium chloride in the generation of plasma thromboplastin[3] showed that the latter four compounds and particularly magnesium chloride are inferior to calcium chloride (Table 1) in this respect.

Plasma thromboplastin was isolated using ether[3]. The product was dissolved in 0·9 per cent sodium chloride and its activation with each of the above compounds was determined by incubating the solution with an equal volume of 0·025 *M* of the compound under trial. At intervals (Table 2), 0·1 ml. of the mixture was taken together with 0·1 ml. of 0·025 *M* calcium chloride and both were added simultaneously to 0·1 ml. human citrated plasma at 37° C., recording the clotting time. The results presented in Table 2 show that strontium and magnesium chloride have no activating effect, while

Table 1. Calcium, Strontium and Magnesium Salts in the Formation of Plasma Thromboplastin

Compounds used	*M*/	Clotting time of substrate in sec. 5	10	20	40	80
Calcium chloride		15	10	8½	8	9½
Calcium gluconate		—	—	10	10	11
Calcium lactate		—	11	9½	9	10½
Strontium chloride		19	15	12½	12	16
Magnesium chloride*		—	54	50	21	23

* Maximum activity was reached after 18 min. incubation, instead of 6 min. with the other compounds.

Table 2. Incubation of Isolated Plasma Thromboplastin with Calcium, Strontium and Magnesium Salts

Compound used (0·025 *M*)	Clotting time of substrate in sec. Period of incubation in min. 0	1	2	4	8
Calcium chloride	26	17	14	14	14
Strontium chloride	23½	23½	23½	24	24
Magnesium chloride	24	24	24	25	25
Calcium lactate	24	21½	20	20½	21
Calcium gluconate	24	22	21	21	21½

calcium lactate and gluconate activate plasma thromboplastin although to a lesser degree than calcium chloride.

From these experiments the development of a fully active plasma thromboplastin seems to be achieved in two stages. In the first stage (or formation stage) the necessary blood-clotting factors interact to form plasma thromboplastin. For this, calcium is needed but can be replaced to a lesser degree by strontium; magnesium is a very poor substitute. In the second stage (or activation stage) the plasma thromboplastin formed is activated by the calcium, thus acquiring its full strength; strontium and magnesium ions cannot replace calcium. Additionally, at this stage the ionic state of the latter appears to affect the degree of activation produced, both calcium lactate and gluconate being less powerful than calcium chloride.

During the process of blood coagulation or in the thromboplastin generation test, the first stage could not be distinguished from the second stage, which follows instantaneously. However, ether-precipitation seems to isolate the non-activated plasma thromboplastin, that is, the product of the first stage. This would explain the apparent low recovery obtained[2]. When the isolated plasma thromboplastin is incubated with calcium chloride, a completely active plasma thromboplastin is obtained after two minutes (Table 2) and the recovery is thus practically doubled in amount.

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[1] Biggs, R., Douglas, A. S., and MacFarlane, R. G., *J. Physiol.*, **119**, 89 (1953).
[2] Nour-Eldin, F., and Wilkinson, J. F., *J. Physiol.*, **132**, 164 (1956).
[3] Biggs, R., and Douglas, A. S., *J. Clin. Path.*, **6**, 23 (1953).

Estimation of Small Proportions of Fœtal Hæmoglobin in Blood

The detailed characterization of blood samples containing the genetically determined abnormal hæmoglobins[1] requires a sensitive method for estimating small traces of fœtal hæmoglobin (Hb-F) in the presence of excess of other hæmoglobins. We have applied the ultra-violet spectrographic method[2] to residues of partially denatured hæmoglobin obtained by a modified Singer procedure[3], with particular attention to the following questions: (*a*) Is the residue authentic hæmoglobin? (*b*) Does it contain fœtal hæmoglobin, and, if so, in what proportion? Residues from normal adult blood, artificial mixtures of adult hæmoglobin (Hb-A) and fœtal hæmoglobin in varying proportions, and pathological blood samples, containing varying proportions of fœtal hæmoglobin by our standard methods, have been studied.

In order to obtain residues of manageable optical density when the proportion of fœtal hæmoglobin is small, our test is carried out by mixing equal volumes of 5 per cent oxy-hæmoglobin solution and $N/6$ sodium hydroxide, giving a final *p*H of about 12·8, and neutralizing in the usual way, but after ¾ min.

Table 1

Sample	¾-min. residue* %	% Hb-F in residue	Protein/hæm ratio of residue	Calculated % Hb-F in sample	% in sample from alkaline denaturation rate
Artificial Hb-A plus Hb-F mixtures					
Normal†	2·1±1·5	Nil.	2·2±0·7	Nil	Nil
1·0% Hb-F	2·8	30	1·8	1·5	Nil
3·0% ,,	4·3	45	1·6	3·1	? trace
5·0% ,,	7·0	50	1·4	5·0	5
7·0% ,,	9·6	65	1·3	7·9	8
10·0% ,,	11·7	70	1·2	10·1	9
15·0% ,,	15·7	75	1·2	14·1	13
30·0% ,,	31·0	85	1·1	29·0	29
Albers–Schönberg disease	3·5	40	1·5	2·1	Nil
Sickle-cell–hæmoglobin *C* disease	6·0	30	1·6	2·9	Nil
Thalassæmia minor, Indian	6·6	25	1·4	2·4	4
Thalassæmia minor, (*a*) Burmese mother	3·3	15–20	2·0	1·1	Nil
(*b*) child of (*a*)	2·3	30	1·9	1·3	? trace
Elliptocytosis with hypochromic anæmia	6·2	Nil	1·4	Nil	Nil

* Measured against Haldane standard with Ilford 625 filter.
† Mean values for 12 normal adult bloods.

The residue from normal adult blood, examined as carboxyhæmoglobin, has a protein/hæm ratio of about 2, as evaluated from the relative absorption intensities of protein and hæm components at selected wavelengths. By the fine-structure criterion[2], the protein is entirely of the adult type in the many samples examined. The spectrographic measurements do not appear to be seriously affected by the presence of free globin.

Table 1 records the results for known mixtures of adult and fœtal hæmoglobin covering a wide range of composition. The proportion of fœtal hæmoglobin in the residue is estimated spectrographically, and that in the whole blood calculated from the percentage residue, after correcting the latter figure for the altered protein/hæm ratio. When the fœtal hæmoglobin is greater than 10 per cent, the residue is a close approximation to the actual fœtal hæmoglobin content. When the fœtal hæmoglobin is less than 10 per cent, however, the residue is higher than the true fœtal content, is no longer pure, fœtal-type hæmoglobin, and its protein/hæm ratio greatly exceeds unity (cf. ref. 4). The data in Table 1 show that errors in the estimation of fœtal hæmoglobin, based on the uncorrected ¾-min. residue, increase progressively as the proportion of fœtal hæmoglobin falls to the 1 per cent level. Similar observations have been made for unmodified Singer 1-min. residues. If corrections are applied for the actual percentage of fœtal hæmoglobin in the residue and for the protein/hæm ratio of the latter, a more accurate estimate is obtained.

Working in this way, it is possible to estimate fœtal hæmoglobin with some confidence down to a level of about 1 per cent of the whole-blood pigment, both in artificial mixtures and in pathological blood samples. At this limit of sensitivity no fœtal hæmoglobin has been found in any of the normal adult hæmoglobins which have been examined. If present, its proportion would seem to be less than 1 per cent, as is claimed by some other workers[3]. Various patho-

logical bloods have yielded more than 2 per cent of residue, but not necessarily containing fœtal hæmoglobin. On the other hand, its presence has been confirmed in other, similar residues when the standard methods do not reveal it in the total hæmoglobin preparations. Examples are given in Table 1, including blood from a child with Albers–Schönberg disease (kindly provided by Prof. C. E. Dent), also a Burmese mother and child with thalassæmia-like anæmias, possessing traces of fœtal hæmoglobin, and small fractions (7 and 14 per cent) of hæmoglobin resembling Hb-E on electrophoresis.

It is evident that the simple and convenient Singer method gives residues of analytical value when the proportion of fœtal hæmoglobin in the sample is more than 10 per cent. When the proportion of fœtal hæmoglobin is less than 10 per cent, however, more laborious examination of the residue is required to detect and estimate the fœtal hæmoglobin which may be present.

We are grateful to the Colonial Medical Research Committee for a grant enabling one of us (M. E.) to assist in this work.

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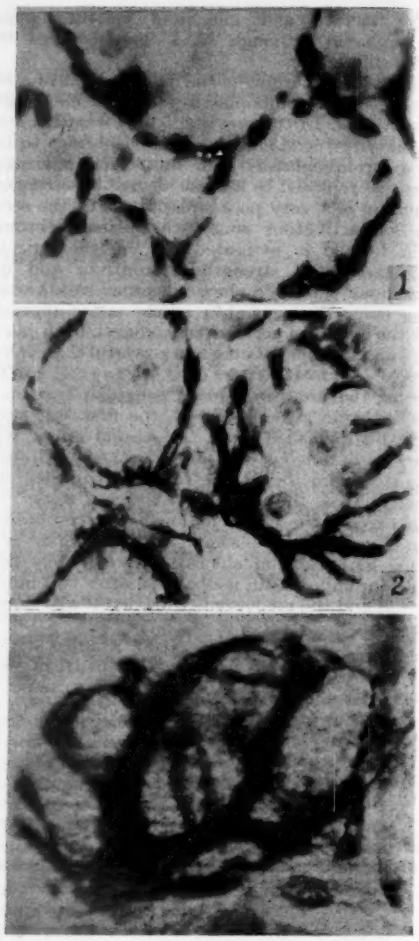
[1] White, J. C., and Beaven, G. H., *J. Clin. Path.*, **7**, 175 (1954). Beaven, G. H., and White, J. C., *Nature*, **172**, 1006 (1953).
[2] Jope, E. M., "Haemoglobin", Barcroft Memorial Volume, 205 (edit. by F. J. W. Roughton and J. C. Kendrew. London, 1949). Beaven, G. H., Hoch, H., and Holiday, E. R., *Biochem. J.*, **49**, 374 (1951).
[3] Singer, K., Chernoff, A. I., and Singer, L., *Blood*, **6**, 413 (1951).
[4] Derrien, Y., *et al.*, *C.R. Acad. Sci., Paris*, **242**, 1538 (1956). Huisman, T. H. J., and Dozy, A., *Biochim. Biophys. Acta*, **20**, 400 (1956).
[5] Chernoff, A. I., *Blood*, **8**, 413 (1953). Huisman, T. H. J., Jonxis, J. H. P., and Dozy, A., *Biochim. Biophys. Acta*, **18**, 576 (1955).

Localization of Alkaline Phosphatase in the Submaxillary Gland of the Rat

In spite of the extensive studies which, in recent years, have been made on the histochemical distribution of alkaline phosphatase, there is a sparseness of data concerning the salivary glands, in particular the submaxillary gland. Gomori[1] commented briefly on the absence of alkaline phosphatase in the parenchymal cells of the salivary glands of man and nine other species, including rat, while Bourne[2] for the guinea pig submaxillary gland reported diffuse staining of nuclei and cytoplasm of the alveolar cells. Deane[3] found alkaline phosphatase localized in the 'basal ergastoplasm' of the serous cells of two submaxillary glands of monkey, and a similar finding was reported by Noback and Montagna[4] for the rat and mouse. The latter workers also mention a heavy reaction of the basement membrane and at other places; but these observations are clouded by the use of excessive times of incubation.

My own paraffin-embedded material of rat submaxillary glands was fixed either in cold acetone or alcohol or preserved by freeze-substitution. Results were essentially identical after any of these methods; but the acetone-fixed material gave the clearer pictures. Alkaline phosphatase was demonstrated both by Gomori's method (substrate: sodium β-glycero-phosphate) and by an azo-dye method



Rat submaxillary glands fixed in acetone and stained by Gomori's method for alkaline phosphatase.
Fig. 1, Incubation time, 30 min. (× 1,010); Fig. 2, incubation time, 30 min. (× 890); Fig. 3, incubation time, 15 min. (× 1,500)

(substrate: sodium α-naphthyl-phosphate). With Gomori's method, a two-hour incubation produced a heavy blackening around and at the base of most acini, thus apparently confirming the observations of earlier workers; but widespread nuclear staining indicated that diffusion was complicating the issue and erroneous interpretation possible[5]. To guard against this, incubation was reduced to 15–30 min. Examination of sections thus treated reveals a definite pattern of this alkaline phosphatase positive material at the base of the acini. It rarely goes right round the acinus but is arranged in an interrupted fashion inside the basement membrane, in the form of dark dots or small rings, short oblique narrow bands or bands running around the circumference of the acinus for a limited stretch (Figs. 1 and 2). Here and there the alkaline phosphatase positive material encloses a nucleus, often oval, distinct from those of the acinar cells and lying against, but inside, the basement membrane. The nature of this pattern, which is suggestive of sections through an irregularly branching network, becomes clear when tangential sections

of acini are seen, showing that it is the 'basket' or myo-epithelial cells which are specifically displayed (Fig. 3). The nucleated parts of these cells when seen from the flat have often a triangular shape from which long branching and tapering processes emanate. The length and width of these agree with the sectioned appearances of the alkaline phosphatase positive material around the acini. It is worth noting that the reaction does not give a homogeneous appearance to the cytoplasm, but rather a mottled one, very often combined with a fibrillar pattern (Figs. 2 and 3).

Similar, but much smaller and less extensively ramifying, alkaline phosphatase positive basket cells were also seen in the very short intercalated ducts which are present in these glands. The remaining portions of the duct system were alkaline phosphatase negative. Blood capillaries gave—as is usual with rat tissue—an irregular and erratic reaction. When alkaline phosphatase was visualized by the azo-dye method, the result was the same.

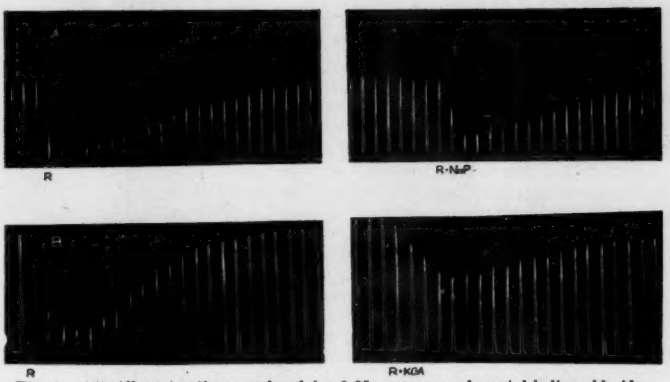


Fig. 1. (*A*) All contractions produced by 0·25 μgm. per ml. acetylcholine chloride. (*B*) All contractions produced by 0·20 μgm. per ml. histamine. At *R*, 30 μgm. per ml. reserpine added. At *R* + *NaP*, 30 μgm. per ml. reserpine and 1 mgm. per ml. sodium pyruvate added. At *R* + *KGA*, 30 μgm. per ml. reserpine and 1 mgm. per ml. α-keto-glutaric acid added

This almost specific localization of alkaline phosphatase in the myo-epithelial cells of the rat submaxillary gland links up satisfactorily with the findings of Dempsey, Bunting and Wislocki[6], who demonstrated the presence of alkaline phosphatase in the myo-epithelial cells of the mammary gland of rat, and of Silver[7], who showed that the same holds for the mammary gland of sheep and rabbit and the sheep's parotid, but it still remains to be seen whether it is a general property of myo-epithelium.

My thanks are due to Dr. F. Jacoby for all his suggestions and helpful criticism, and to Mr. L. Jones for the microphotographs.

Addendum.—Since this communication was submitted for publication, my attention has been directed to a letter by R. L. Holmes (*Nature*, **178**, 311 (1956)).

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[1] Gomori, G., *J. Cell Comp. Physiol.*, **17**, 71 (1941).
[2] Bourne, G., *Quart. J. Exp. Physiol.*, **32**, 1 (1943).
[3] Deane, H. W., *Amer. J. Anat.*, **80**, 321 (1947).
[4] Noback, C. R., and Montagna, W., *Amer. J. Anat.*, **81**, 343 (1947).
[5] Martin, B. F., and Jacoby, F., *J. Anat.*, **83**, 351 (1949).
[6] Dempsey, E. W., Bunting, H., and Wislocki, G. B., *Amer. J. Anat.* **81**, 309 (1947).
[7] Silver, I. A., *J. Physiol.*, **125**, 8P (1954).

Antagonists of the Action of Reserpine on Smooth Muscle

We have recently directed attention to the fact that citrate antagonizes reserpine inhibition of contractions induced in the guinea pig ileum by acetylcholine chloride, histamine acid phosphate, serotonin and barium chloride[1]. A consideration of the general pharmacology of reserpine has led us to believe that this substance may have a general non-specific depressant effect upon contractile tissue[1,2].

Since reserpine non-selectively antagonizes contractions due to acetylcholine chloride, histamine acid phosphate, serotonin and barium chloride in the guinea pig ileum, it appears to be affecting underlying mechanisms connected with the production and utilization of the energy necessary for the drug-induced contractions rather than specific receptors. These mechanisms probably involve the breakdown and resynthesis of carbohydrate through the glycolytic and tricarboxylic acid cycles. It seemed worth while, therefore, investigating the influence of adding known intermediates of carbohydrate metabolism to the isolated guinea pig ileum immediately before addition of reserpine.

The ileum was stimulated by either acetylcholine chloride (0·2–1·0 μgm. per ml.), histamine acid phosphate (0·1–1 μgm. per ml.), serotonin (15–40 mgm. per ml.) or barium chloride (0·2 mgm. per ml.) at 3-min. intervals. Reserpine was added 1 min. before the spasmogen and the metabolite 5 sec. before reserpine. All metabolites were tested over the dose-range, 125 μgm.–1 mgm. per ml. The following were ineffective as reserpine antagonists: glucose-1-phosphate, fructose-1,6-diphosphate, fructose-6-phosphate, pyruvate (Fig. 1), fumarate, succinate and adenosine triphosphate. The following were very active: citrate, *cis*-aconitate and α-keto-glutarate (Fig. 1). Malate and oxaloacetate had intermediate activity. Maleic acid (the *cis*-isomer of fumaric acid) at doses of 500 μgm. or 1 mgm. per ml. was very active. Removal of calcium from the bath fluid by disodium dihydrogen versenate did not produce antagonism to reserpine.

The possibility of release of histamine or acetylcholine chloride by the metabolites was excluded by repeating the experiments using, where appropriate, Tyrode's solution containing either atropine sulphate (100 μgm. per litre) or mepyramine maleate (200 μgm. per litre).

Since the most active reserpine antagonists are intermediates of the tricarboxylic acid cycle, it seems not unlikely that this is a site of action of the alkaloid.

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[1] Gillis, C. N., and Lewis, J. J., *J. Pharm. Pharmacol.*, **8**, 606 (1956).
[2] Lewis, J. J., *J. Pharm. Pharmacol.*, **8**, 465 (1956).

Bleaching of Visual Purple in Solutions of Inorganic Salts

It has been stated that visual purple can be salted out of solution with magnesium and sodium sulphates[1,2]. In the present work, an attempt was made to repeat this, using moderately concentrated visual purple solutions. No precipitation occurred; but it was found that in the presence of large amounts of ammonium sulphate, ammonium chloride, magnesium sulphate and sodium sulphate the bleaching of visual purple was modified.

Solutions of frog visual purple were prepared by the addition of 1 per cent aqueous digitonin solution to whole washed retinæ. The extracts were buffered to *p*H 8·0–8·6 by the addition of sodium tetraborate solution. These extracts were then concentrated about 3–4 times *in vacuo* at low temperature, bringing the D_{500} from 0·2 to 0·6–0·8.

Saturation of these solutions with ammonium sulphate (making the salt concentration about 3·3 *M* and bringing the *p*H to about 7·2) produced only a faint opalescence. On exposure to light, such solutions bleached to a stable orange photo-product. The absorption spectra for a bleached and unbleached solution are shown respectively by curves *A* and *B* of Fig. 1. The $\lambda_{max.}$ of the unbleached solution lies at 495 mμ, and that of the bleached solution at 470 mμ. The true pigment maxima may be obtained by calculating the $D_{min.}/D_{max.}$ ratios and correcting the observed maxima accordingly[3]. When this is done, the corrected $\lambda_{max.}$ of the unbleached and bleached solutions are seen to lie at 501 mμ and 482 mμ respectively.

The orange photo-product was clearly not indicator yellow, for the $\lambda_{max.}$ of that substance, even in acid solution, is no higher than 440 mμ. If another portion

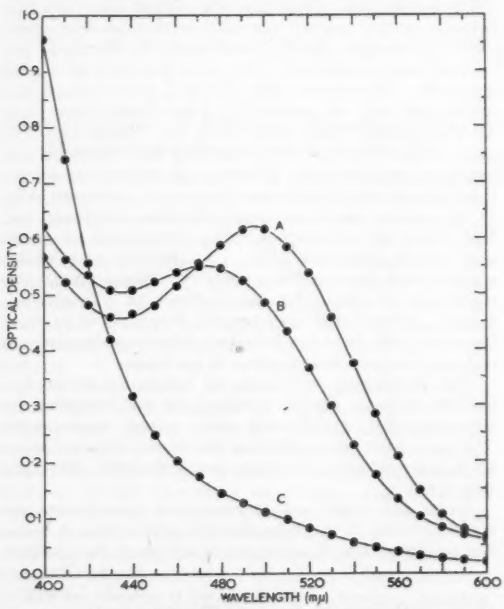

Fig. 1. Absorption spectra of visual purple extracts saturated with ammonium sulphate.
Curve *A*, Extract saturated with ammonium sulphate (*p*H = 7·19, $D_{min.}/D_{max.}$ = 0·74); curve *B*, extract after a 15 min. exposure to white light ($D_{min.}/D_{max.}$ = 0·91); curve *C*, the same visual purple extract bleached prior to saturating with ammonium sulphate

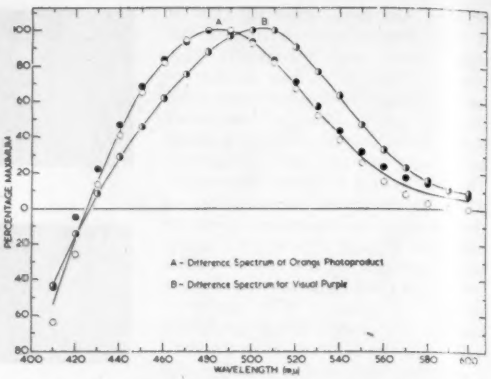
PERCENTAGE MAXIMUM
WAVELENGTH (mμ)
A - Difference Spectrum of Orange Photoproduct
B - Difference Spectrum for Visual Purple

Fig. 2. Difference spectra of the orange photo-product and of visual purple.
●, Curve *B* minus *C* (Fig. 1); ○, difference spectrum, as above; the data are obtained from a similar extract (*p*H = 6·96); ◑, curve *A* minus *C* (Fig. 1)

of the same visual purple solution was bleached prior to saturating with ammonium sulphate a normal alkaline indicator yellow curve was obtained. This is shown in curve *C*, Fig. 1. The 'difference spectrum' of the orange photo-product is obtained by subtraction of curve *C* from curve *B*. This is shown in Fig. 2. The $\lambda_{max.}$ lies at 485 mμ, thus confirming the value of 482 mμ calculated directly from the solution. Subtraction of curve *C* from curve *A* yields a difference spectrum for visual purple. This also is shown in Fig. 2.

In darkness at 20° C. the orange photo-product slowly transformed to indicator yellow over a period of about 48 hr. Heating the solution for 15 min. at 60° C. caused destruction of the orange photo-product, accompanied by the formation of a pale yellow gel. If the salt concentration were reduced by the addition, in darkness, of an equal volume of 4 per cent aqueous digitonin solution the orange photo-product changed to alkaline indicator yellow. The transformation was complete in about 20 min.

When concentrated visual purple solutions were saturated with magnesium sulphate, sodium sulphate or ammonium chloride, then exposed to light, the orange photo-product was formed initially but was more unstable. After about ½ hr. in darkness, only indicator yellow was left in solution.

Whenever these solutions were diluted or were stored for any length of time, unpredictable changes in opalescence occurred. It was often difficult, therefore, to attain the desired accuracy in the measurement of absorption spectra.

Under certain conditions visual purple is known to produce stable orange photo-products. At low temperatures, Lythgoe[4] found that visual purple bleached to form transient orange, $\lambda_{max.}$ estimated at about 470 mμ [5]. At room temperatures, visual purple in a dried gelatin film bleaches to meta-rhodopsin, $\lambda_{max.}$ 480 mμ [6].

Judged by its $\lambda_{max.}$ and its absorption properties, the orange photo-product of the present work is identical with meta-rhodopsin. One difference, however, may be noted: meta-rhodopsin which has been produced in a dried film may be converted by wetting to indicator yellow ('retinene$_1$ and protein') and 'regenerated rhodopsin'[6]. The analogous process in the present work, reduction of salt concentration by dilution, completely converts the orange photo-

product to indicator yellow, there being no sign of 'regeneration'.

It is interesting to note that Lythgoe and Quilliam[7] found that the velocity constant for the thermal conversion of visual purple to indicator yellow at 36° C. was diminished about five times in the presence of 2 *M* sodium chloride. The effect was probably due to the stabilization by salt of an orange intermediate.

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[1] Kühne, W., *Untersuch. Physiol. Inst. Heidelberg*, **1**, 15 (1877).
[2] Chase, A. M., and Haig, C., *J. Gen. Physiol.*, **21**, 411 (1938).
[3] Crescitelli, F., and Dartnall, H. J. A., *J. Physiol.*, **125**, 607 (1954).
[4] Lythgoe, R. J., *J. Physiol.*, **89**, 331 (1937).
[5] Lythgoe, R. J., and Quilliam, J. P., *J. Physiol.*, **94**, 399 (1938).
[6] Wald, G., Durell, J., and St. George, R. C. C., *Science*, **111**, 179 (1950).
[7] Lythgoe, R. J., and Quilliam, J. P., *J. Physiol.*, **93**, 24 (1938).

Amino-Acid Sequence in a Fraction of *Bombyx* Silk Fibroin

When an aqueous solution of the fibroin of *Bombyx mori* is acted upon by chymotrypsin, a precipitate is formed[1] through the specific action of the enzyme on the α-carboxyl groups of the tyrosine residues. This precipitate contains 62 per cent of the total nitrogen and represents 58 per cent of the total weight of the protein. It consists almost entirely of glycine, alanine, and serine, together with a little tyrosine, the molar ratios of glycine to alanine to serine being 3 to 2 to 1. The fraction has a high degree of crystalline order as shown by X-rays, and a molecular weight of about 4,000.

A detailed analysis[2] of this chymotryptic precipitate has established its formula as $Gly._{2}\ Ala._{2}\ Ser._{1}\ Tyr._{1}$, and the C-terminal position has been shown to be occupied mainly by tyrosine[3].

We have recently investigated the sequence of the amino-acids in the chymotryptic precipitate. This investigation has been greatly facilitated by the absence from hydrolysates of the chymotryptic precipitate of Gly.Gly, which could not be detected even after careful search in a number of separate experiments. The absence of Gly.Gly bonds, and the analytical values showing that one half of the total residues are glycyl, mean that every alternate residue must be glycine. If the seryl residues are evenly spaced within the molecule, they will occupy every sixth position, and a repeating hexapeptide sequence of the form Ser.Gly.Ala.Gly.Ala.Gly would be a dominant feature of the molecule.

By using the N-acyl to O-acyl transformation that occurs at the seryl residues when proteins are dissolved in anhydrous mineral acids[4,5], followed by specific fission at these residues, we have been able to isolate and identify 36 per cent by weight of the chymotryptic precipitate as this hexapeptide in the form of its dinitrophenyl derivative. The yield would undoubtedly be considerably greater, but for the difficulty of preventing unwanted fission and re-combination during the treatment.

The products of the partial hydrolysis of the chymotryptic precipitate have also been examined, the dinitrophenylated mixtures being separated by column chromatography into their constituents, which were estimated quantitatively, a maximum recovery of 87 per cent, on a nitrogen basis, being obtained. The only dipeptides recovered were Ala.Gly, Gly.Ala, Ser.Gly, and a very small amount of Ala.Ala. The only tripeptides obtained were Gly.Ala.Gly, Ala.Gly.Ala, and Ser.Gly.Ala. The molar ratio of Ala.Gly to Gly.Ala in hydrolysates of periods longer than five hours was consistently 2 to 1. Serine was never recovered in peptide form except as the N-terminal residue, and was followed always by glycine, and not by alanine.

The N-terminal amino-acid residues of the chymotryptic precipitate have been determined by treating it with 1-fluoro-2 : 4 dinitrobenzene, hydrolysing, and separating and estimating the dinitrophenyl-amino-acids. Glycine occupied 84 per cent of the N-terminal amino positions, serine 10 per cent and alanine 4 per cent. Dinitrophenyl-Gly.Ala, dinitrophenyl-Gly.Ala.Gly, and dinitrophenyl-Gly.Ala.Gly.Ala were isolated from the N-terminal sequence, and, together with the recovered dinitrophenyl-glycine, they constituted 78·5 per cent of the total N-terminal glycine.

Consideration of all the evidence leads to the conclusion that the chymotryptic precipitate is composed mainly of a repeating sequence of the form $Ser.Gly.(Ala.Gly)_{n}$, where n is usually 2, and must have, by requirement of the analytical data, an *average* value of 2. In addition to this principal constituent, a small amount of Ala.Ala is present, together with a C-terminal tyrosine residue and an N-terminal sequence in which mainly glycine provides the N-terminal amino residue.

The chymotryptic precipitate is thus composed of an aggregation of sections of the fibroin molecule, these sections having the formula

$$Gly.Ala.Gly.Ala.Gly.[Ser.Gly.(Ala.Gly)_{n}]_{8}\ Ser.Gly.Ala.Ala.Gly.Tyr.$$

where n is usually 2, and always has a mean value of 2.

A detailed account of this work has been prepared, and is being submitted for publication elsewhere.

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[1] Drucker, B., Hainsworth, R., and Smith, S. G., Shirley Inst. Mem., **26**, 191 (1953); *J. Text. Inst.*, **44**, T.420 (1953).
[2] Lucas, F., and Smith, S. G. (unpublished).
[3] Shaw, J. T. B., and Smith, S. G., *J. Text. Inst.*, **45**, T.939 (1954).
[4] Desnuelle, P., and Bonjour, G., *Biochim. Biophys. Acta*, **7**, 451 (1951).
[5] Elliott, D. F., *Biochem. J.*, **50**, 542 (1952).

Interrelation between Photosynthesis and Respiration in the Marine Flagellate, *Dunaliella euchlora*

The photosynthetic assimilation of carbon-14 from the external medium by unicellular algae appears to proceed at a rate which is equivalent to the plants' net photosynthesis (the difference between photosynthesis and respiration). This was demonstrated in experiments in which the assimilation of carbon-14 was compared simultaneously with the evolution of oxygen[1], and was most apparent under conditions of low light intensity or nutrient depletion where respiration approached or equalled photosynthesis. For example, at or below the compensation-level no significant uptake of carbon-14 could

be detected in 24 hr. despite the occurrence of measurable photosynthesis by oxygen production.

Two possible physiological explanations for this behaviour have been considered. These are: (1) that newly assimilated carbon serves as an immediate substrate for respiration; (2) that respiratory carbon dioxide is used preferentially to external carbon dioxide for photosynthesis. The first of these explanations appears to be contradictory to the findings of Calvin[3] and Weigl *et al.*[3], who have reported that newly assimilated carbon-14 does not immediately enter the respiratory cycle as long as the plants are photosynthesizing.

The second possibility may be investigated by a simple experiment in which organisms are grown in a medium containing carbon-14 for a sufficient number of generations so that essentially all their carbon becomes uniformly labelled with the tracer. If the cells are then removed from their external carbon-14 source and resuspended in fresh medium, any respiratory loss of carbon must be accompanied by a loss of carbon-14 activity by the organisms. The failure to detect such a loss during photosynthesis would clearly demonstrate the re-assimilation of respiratory carbon dioxide. The details of such an experiment are as follows.

A bacteria-free culture of *Dunaliella euchlora* was inoculated into 1·5 litres of enriched sea water medium deficient in nitrogen (0·001 per cent potassium nitrate), giving an initial cell concentration of 1,500 cells/ml. 10 μc. of $^{14}CO_2$ were added and the cultures exposed to approximately 800 foot-candles of illumination at 20° C. At the same time a duplicate culture containing no carbon-14 was inoculated. After two days the cultures contained 21,000 cells/ml. and, for practical purposes, all the carbon of the cells in the isotope-enriched culture was uniformly labelled with the tracer. Exponential growth continued for four days and growth stopped after the fifth day. During the growth period sufficient carbon dioxide was added daily to keep the *p*H below 8·0. This was not necessary after growth had stopped. The growth-curve for the two duplicate cultures is shown in Fig. 1, each point representing the mean concentration of cells in the two cultures.

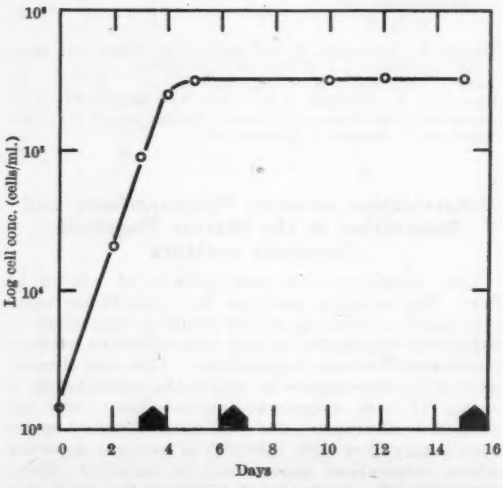

Fig. 1. Growth curve of duplicate *Dunaliella* cultures. Arrows denote days on which experiments were performed.

Table 1. The Loss of Activity in *Dunaliella* tagged with Carbon-14 in the Light and Dark in relation to Photosynthesis and Respiration

Age of culture (days) (see Fig. 1)	*P*	*R* (ml. O_2/l./hr.)	*P* : *R*	% Loss activity/24 hr. Light	Dark
3	0·36	0·03	12·0 : 1	−0·3*	20·9
6	0·09	0·02	4·5 : 1	1·6*	22·9
15	0·03	0·015	2·0 : 1	1·5*	20·0

* Attributable in each case to random counting error.

On the third, sixth and fifteenth days aliquots of the culture tagged with carbon-14 were centrifuged. The cells were then washed in filtered sea water and resuspended in the filtered medium of the culture containing no carbon-14, adjusting the density to give 25,000 cells/ml. The tagged cells were thereby removed from their external source of carbon-14 but retained in a medium physiologically identical with that in which they had grown. The *p*H was adjusted to 7·0–7·5 by the addition of carbon dioxide and the new cell suspension siphoned into 35-ml. glass-stoppered bottles.

Half the bottles were used for the determination of photosynthesis and respiration by measuring the change in dissolved oxygen concentration (Winkler method) in the light (800 f.c.) and in the dark after six hours. The increase in oxygen in the light represents net photosynthesis ($P-R$), the decrease in the dark represents respiration (R) and the difference between the two is considered equivalent to total photosynthesis (P).

Of the remaining bottles, one-third were filtered immediately, one-third exposed to 800 foot-candles illumination for 24 hr. and filtered, and one-third kept in the dark for 24 hr. and filtered. The filters were then dried and their radioactivity determined. All the above measurements were made in triplicate, and the mean values are given in Table 1. The data show that the cells tagged with carbon-14 did not lose a significant amount of carbon during 24 hr. of exposure to light, while those kept in the dark for the same length of time lost approximately 20 per cent of their carbon.

Measurements of the oxygen assimilation of *Dunaliella* following its removal from light have shown that respiration proceeds at a rapid and constant rate during the first 24 hr., after which the process slows down markedly. Kok[4] observed the same behaviour in *Chlorella*, which respired as much as 15 per cent of its dry weight (or a comparable fraction of its carbon) in 20 hr., following which the rate of oxygen uptake "declined to a low and steady level of endogenous respiration".

The loss of 20 per cent of the carbon-14 content of the cells in the dark over 24 hr. may therefore be reasonably attributed to respiration. Since the rate of oxygen uptake remains constant throughout that period, it also seems reasonable to assume that respiration occurred at essentially the same rate in the organisms exposed to the light, particularly in view of the evidence presented by Brown[5] that respiration is independent of light.

Since all carbon in the organisms was tagged with carbon-14, any measurable respiration would result in a loss of activity to the cells. The fact that such a loss was not detected in the light must be interpreted to mean that somewhere within the respiratory cycle the carbon was re-assimilated by photosynthesis. This process appears to have occurred with 100 per cent efficiency regardless of the rate of photosynthesis or

the ratio of $P : R$. It is noteworthy that the respiratory carbon dioxide was preferentially used despite an external partial pressure of carbon dioxide more than four times as great as that of normal sea water. Even during the period of maximum photosynthesis (on the third day) carbon dioxide assimilation did not exceed 15 per cent of the total carbon dioxide available in the medium.

These experiments provide no clue as to the biochemical state of the recycled respiratory carbon. They recall the suggestion of Franck[6], Gaffron[7] and others of a common intermediate pool for photosynthesis and respiration. However, a case may also be made on purely physical grounds for the successful competition of respiratory versus external carbon dioxide at the chloroplast. The latter is perhaps more compatible with the observations of Brown[5], who was able to neglect the preferential utilization of photosynthetically produced oxygen in his respiration experiments with *Chlorella*, indicating that the two processes are not universally linked at an intermediate level.

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[1] Ryther, J. H., *Deep-Sea Res.*, **2**, 134 (1954); *Limnol. and Oceanogr.*, 1 (2), 72 (1956).
[2] Calvin, M., *J. Chem. Ed.*, **26**, 639 (1949).
[3] Weigl, J. W., Warrington, P. M., and Calvin, M., *J. Amer. Chem. Soc.*, **73**, 5058 (1951).
[4] Kok, B., *Acta Bot. Néerl.*, **1**, 445 (1952).
[5] Brown, A. H., *Amer. J. Bot.*, **40**, 719 (1953).
[6] Franck, J., *Arch. Biochem.*, **45**, 190 (1953).
[7] Gaffron, H., 4th Symp. Soc. Gen. Microbiol., 152 (Camb. Univ. Press, 1954).

Insecticide Resistance in *Anopheles gambiae* Giles: a Case of Simple Mendelian Inheritance

A STRAIN *of Anopheles gambiae* from Northern Nigeria, highly resistant to dieldrin and cross-resistant to the related chlorinated hydrocarbon insecticides (chlordane, aldrin, isodrin, endrin and gamma-BHC), but still susceptible to DDT, has recently been colonized in this Institute and the degrees of resistance to these insecticides reported[1]. A colony of the same species from Lagos and susceptible to all these insecticides has also been maintained in the same Institute for some four years.

Crossings between the two strains have now thrown light on the mechanism of the inheritance of this particular type of resistance in *A. gambiae*.

Crossings have been possible both ways (male × female and female × male), and result in hybrids which are identical and homogeneous so far as their susceptibility to insecticides is concerned (so far only gamma-BHC and dieldrin have been tried).

Table 1. MEDIAN LETHAL CONCENTRATIONS (PERCENTAGES IN RISELLA OIL) OF DIELDRIN AND GAMMA-BHC WHEN SUSCEPTIBLE, RESISTANT AND HYBRID STRAINS OF *Anopheles gambiae* ARE EXPOSED FOR 1 HR.

	Susceptible strain (*S*) ♀	Susceptible strain (*S*) ♂	Resistant strain (*R*) ♀	Resistant strain (*R*) ♂	Hybrid *R*♀ × *S*♂ ♀	Hybrid *R*♀ × *S*♂ ♂	Hybrid *R*♂ × *S*♀ ♀	Hybrid *R*♂ × *S*♀ ♂
Dieldrin	0·08	0·05	>4·0	>4·0	2·6	1·5	2·3	1·6
Gamma-BHC	0·007	0·006	0·21	0·18	0·053	0·038	0·052	0·038

Homogeneity is indicated by the narrow range of dosages of these insecticides necessary to kill all these hybrids, the dosages being between those necessary to kill the susceptible strain and those necessary to kill the resistant strain. Table 1 shows the *LD*50 for the two strains and the two hybrids when exposed for 1 hr. to solutions of dieldrin and gamma-BHC in Risella oil[2]. The *LD*50 of dieldrin was impossible to determine for the resistant strain when exposure for 1 hr. only was made, as a saturated solution of this insecticide (4 per cent) gave no kill. By increasing the exposure time, however, it has been shown to be about 800 times as resistant to dieldrin when compared with the Lagos strain, and is also some twenty-six times as resistant to gamma-BHC[1]. The hybrids proved to be some thirty times as resistant to dieldrin and seven times to gamma-BHC. The males of both strains were slightly more susceptible than the females.

Thus it has been possible to choose two separating dosages of both insecticides, one killing all susceptibles but not hybrids or resistants, and the other killing all hybrids and susceptibles but not resistants. These dosages for an exposure of 1 hr. are 0·33 and 4·0 per cent dieldrin and 0·025 and 0·1 per cent gamma-BHC.

The usual method of determining the number of genes involved in a particular character by ascertaining the sort-out in the F_2 generation was not possible with these two strains of *A. gambiae*, because the F_1 hybrids were almost sterile. Though eggs were readily laid by the hybrid females, only a very occasional one proved to be viable. The sterility was eventually shown to be in the male hybrid.

It has been possible, however, to back-cross the two hybrid females with the parent susceptible and resistant males. The offspring of the four possible back-crosses have been exposed to the established separating dosages and the resulting proportions of susceptibles, hybrids and resistants obtained are given in Table 2. These results show quite conclusively that the inheritance of resistance to the dieldrin–chlordane–gamma-BHC group of insecticides is monofactorial with incomplete dominance.

A complete proof of this 50 : 50 separation in the offspring of the back-cross was given when the offspring of the back-cross of the hybrid female (*R*♀ × *S*♂) with the susceptible male parent were exposed to the dosage eliminating susceptibles and the survivors

Table 2. PERCENTAGES OF SUSCEPTIBLES, HYBRIDS AND RESISTANTS RESULTING FROM THE FOUR BACK-CROSSES OF THE TWO HYBRID (*RS*) FEMALES WITH THE PARENT RESISTANT (*R*) AND SUSCEPTIBLE (*S*) MALES
The actual numbers of mosquitoes involved are given in brackets

Parents	*R*♀ × *S*♂				*R*♂ × *S*♀			
Back-cross	*RS*♀ × *S*♂		*RS*♀ × *R*♂		*RS*♀ × *S*♂		*RS*♀ × *R*♂	
Back-cross offspring	Susceptible	Hybrid	Resistant	Hybrid	Susceptible	Hybrid	Resistant	Hybrid
Males	57 (384)	43 (295)	48 (167)	52 (181)	49 (195)	51 (202)	45 (133)	55 (161)
Females	49 (364)	51 (380)	51 (241)	49 (23 ·)	56 (194)	44 (150)	49 (195)	51 (207)

were crossed with the resistant male parent. Subsequent offspring were exposed to the dosage killing hybrids and the following proportions obtained :

	Hybrids	Resistants
Males	53 per cent (86)	47 per cent (75)
Females	41 per cent (119)	59 per cent (170)

The surviving males and females from this latter exposure, on being crossed with the parent resistant strain, yielded pure resistant strains again.

In addition to the selection of this resistant strain from the back-cross of the hybrid with the susceptible parent, the offspring of this back-cross were shown to be composed of hybrids and susceptibles only, by exposing them to the dosage which kills hybrids. Such exposure resulted in 100 per cent kill. Similarly, exposure of the offspring of the back-cross of the hybrid with the resistant parent to a dosage which kills susceptibles only resulted in no kill at all.

This finding of a monofactorial inheritance of resistance indicates the necessity for a change in the method of detecting resistance in the field. The present method of comparing the *LD*50 of a particular insecticide in an insect population where resistance is suspected with that in a population where the insecticide has never been used may show only a small difference, in some cases not even statistically significant, depending on the proportions of the three groups (susceptibles, hybrids and resistants) in the population examined. Thus, in Western Sokoto, from where these dieldrin-resistant *A. gambiae* originated, the degree of resistance was recorded[3] as only eight times in 1955. The use of separating or discriminating dosages would have enabled a selection of the pure resistant strain, which is in fact some 800 times as resistant as the susceptible. It is suggested, therefore, that instead of a comparison of *LD*50 in the two populations, the minimum *LD*100 be established in the susceptible population, and the suspected population exposed to this dosage. Survivors, if any, can then be reared and their offspring exposed to higher dosages to select the resistant strain.

Alternatively, an accurate dosage/mortality regression line can be made in the suspected area, using a large number of dosages of the insecticide. If resistance is present, it will be shown by two steps in the line where increase in dosage produces no change in kill. These are the discriminating dosages between susceptibles and hybrids and between hybrids and resistants.

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[1] Davidson, G., *Nature* [178, 705 (1956)].
[2] World Health Org., Tech. Series Report No. 80 (1954).
[3] Elliott, R., and Ramakrishna, V., *Nature*, 177, 532 (1956).

Copper Deficiency in Sitka Spruce Seedlings

For several years a symptom referred to as 'needle tip-burn'[1-3] has been observed in Sitka spruce seedlings at the Forestry Commission Research Nursery, Sugar Hill, near Wareham, Dorset. The nursery, which occupies land formerly covered by *Calluna* and scrub pine, is on a highly leached sandy soil over Bagshot Sands (Lower Eocene), with a humus and iron pan at varying depth. To break the pan, most parts of the nursery have been subsoiled in recent years.

'Needle tip-burn' usually appears during dry hot spells in midsummer, the damage being confined to the more vigorously growing seedlings. The tips of the upper needles shrivel and turn straw colour. There is a distinct break between the normal green lower part of the needle and the withered upper part, and in many cases a ring-like structure separates the healthy from the shrunken portion. The symptom is often accompanied by a spiral twist of the upper needles. If dry hot weather persists for a long period, plants rarely recover and the growing point dies. Later in the summer the upper needles turn brown or black and carry infections of *Botrytis* or other fungi. If the hot spell lasts for only a short time and is followed by moist conditions most of the new needles that emerge are free from tip-burn, and all that is left to indicate the earlier attack is a ring of damaged needles lower down the stem.

Whereas 'needle tip-burn' is common on seedlings grown with inorganic fertilizers, damage has only rarely been observed on seed-beds treated with a compost made from hop-waste and chaffed green bracken. In an early experiment in which a variety of composts were compared, only those containing hop-waste prevented tip-burn.

The resemblance of 'needle tip-burn' to 'withered tip disease' in cereals, its mode of occurrence and the incidence of copper deficiency in fruit trees on Bagshot Sands[4-6], suggested that the symptoms in Sitka spruce might also be due to lack of copper. In June 1955, therefore, a foliar spray of copper sulphate was applied to half the plots in an experiment on Sitka spruce seedlings grown with inorganic fertilizers. The spray supplied 0·16 gm. copper per square yard in 300 ml. water, that is, a solution with about 0·05 per cent copper. Five weeks after application the untreated plots were beginning to suffer from tip-burn but the sprayed plots were completely free. Later in the season tip-burn became severe on the no-copper plots ; slight symptoms were, however, visible on the plots treated with copper sulphate. Table 1 shows visual 'scores' for needle damage taken on four different occasions, seedling height in inches at the end of the growing season and the copper content of the whole seedling.

The copper sulphate spray increased seedling height by nearly 50 per cent and copper content by 40 per cent ; but it did not completely remove the symptoms, and higher rates of application are therefore being tested in 1956.

In seed-bed experiments laid down in 1951 at Sugar Hill Nursery, Wareham, and at Kennington Nursery, near Oxford, a standard inorganic fertilizer has been compared each year with a compost made from bracken and hop-waste. In 1955 the fertilizer plots at Wareham showed considerable tip-burn but the compost plots were free. No tip-burn symptoms have ever been observed on either treatment at Kennington, a sandy loam over Jurassic Calcareous

Table 1. Sitka Spruce Seedlings at Wareham Nursery, 1955

	Visual 'scores' for 'needle tip-burn'				Mean height (in.)	Cu in dry matter of seedling (p.p.m.)
	Aug. 4	Aug. 11	Aug. 23	Oct. 6		
Untreated	2·4	3·4	4·4	5·1	1·9	2·3
Copper spray	0·0*	0·0	1·0	2·2	2·8	4·2

*0·0 means no damage

Table 2. SITKA SPRUCE SEEDLINGS 1955

	Visual 'scores' for 'needle tip-burn'		Cu in dry matter of seedling (p.p.m.)	
	Wareham	Kennington	Wareham	Kennington
Fertilizer	3	0	2·8	10·8
Compost	0	0	7·0	10·4

(0 = no damage)

Grit. Visual 'scores' and copper contents of the crops are shown for both centres in Table 2.

The results of analysis of several batches of bracken and hop-waste (Table 3) show that, whereas the copper content of bracken was around 10 parts per million, the value for hop-waste approached the 1,000 parts per million level. A sample of unextracted hops was found to contain only 95 parts per million, so that a large fraction of the copper in the hop-waste presumably came from sources at the brewery such as copper boilers used in the extraction of the hops.

Table 3. COPPER CONTENT OF HOPS, BRACKEN AND BRACKEN HOP-WASTE COMPOST

	Cu in dry matter (p.p.m.) Range	Mean
Hops	—	95
Hop-waste ('spent hops')	865–970	910
Bracken	11–13	12
Bracken hop-waste compost	340–465	365

The absence of tip-burn on the Sitka spruce seedlings grown with bracken hop-waste compost can therefore be ascribed to the high copper content of the compost.

The experiments discussed in this communication are part of an investigation carried out in intimate collaboration with the Research Branch of the Forestry Commission.

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[1] Crowther, E. M., Warren, R. G., and Benzian, B., Rep. For. Res. For. Comm. Lond. 1952/3, 84 (1954).
[2] Benzian, B., Rep. For. Res. For. Comm. Lond. 1953/4, 38 (1955).
[3] Rothamsted Experimental Station. Rep. Rothamst. Exp. Sta. for 1955 (1956).
[4] Jones, J. O., *Nature*, **165**, 192 (1950).
[5] Bould, C., *et al.*, *Nature*, **165**, 920 (1950).
[6] Pizer, N. H., *J. Roy. Agric. Soc.*, **116**, 68 (1955).

αε-Diaminopimelic Acid in the Peptide Moiety of the Cell Wall Polysaccharide of *Bacillus anthracis*

Bacillus anthracis contains a polysaccharide which appears to be part of the cell wall[1]. Ivanovics[2] first isolated the polysaccharide which contained galactose 34 per cent, glucosamine 34 per cent, nitrogen 4·2 per cent and α-carboxyl amino-nitrogen 0·8 per cent. Strange and Belton[3] obtained from culture filtrates of *B. anthracis* a polysaccharide which contained galactose 39–43 per cent, glucosamine 34 per cent, nitrogen 3·9 per cent and α-carboxyl amino-nitrogen 1·26 per cent. The differences between the total nitrogen and glucosamine nitrogen values together with the figures for α-carboxyl amino-nitrogen in these preparations indicated the presence of 5–10 per cent of amino-acid residues. Smith and Zwartouw[4] obtained a polysaccharide from *B. anthracis* grown *in vivo*. It contained galactose 38–43 per cent, glucosamine 38–44 per cent, nitrogen 4·0 per cent and α-carboxyl amino-nitrogen 0·3 per cent. Since this preparation satisfied a number of rigorous tests for homogeneity it was concluded that a small peptide moiety (2–3 per cent) was firmly attached to the polysaccharide. We are concerned here with the constitution of this peptide moiety.

The amino-acids detected in the polysaccharide preparations were alanine, aspartic acid, glutamic acid and glycine[3,4]. This restricted amino-acid content was peculiar and only recently recognized as resembling that of the peptides containing αε-diaminopimelic acid and an unidentified amino-sugar, which form part of the walls of some bacteria[5] and spores[6]. Two samples of the polysaccharide as isolated from *B. anthracis*[3,4] have therefore been re-examined with the object of detecting the presence of small quantities of αε-diaminopimelic acid and unidentified amino-sugar; both compounds were found.

(1) *Detection of αε-diaminopimelic acid.* Samples (25 mgm.) were hydrolysed (6 *N* hydrochloric acid, 100°, 16 hr.) and the hydrolysate after evaporation was run as a band on a paper chromatogram using collidine/lutidine/water as solvent and synthetic αε-diaminopimelic acid as standard. After examination in ultra-violet light, strips of paper in positions equivalent to the standard were eluted with water. Portions of the evaporated eluates (equivalent to at least 6 mgm. of the original polysaccharide) were compared with synthetic αε-diaminopimelic acid on chromatograms using the solvent of Rhuland, Work, Denham and Hoare[7]. αε-Diaminopimelic acid (meso and/or DD isomers) was found in both samples of polysaccharide and its approximate concentration was 0·1–0·2 per cent.

(2) *Detection of the unidentified hexosamine of Strange and Powell*[4]. Samples (20–30 mgm.) were hydrolysed (6 *N* hydrochloric acid, 3 hr., 100°) and the hydrolysate evaporated, redissolved, neutralized with *IR*-4*B*(OH) and filtered. Almost all the glucosamine was removed from the filtrates by treating them for 20 min. with *IR*-120 (2 gm.) which had been buffered at *p*H 6·05[8]. After removal of the resin, the filtrates were analysed for hexosamine by the Elson and Morgan method and contained 0·6–1·0 per cent calculated on the weight of polysaccharide taken. In this analysis, the absorption maximum of the coloured derivatives were near 520 mμ ($\frac{-\log T\ 530}{-\log T\ 520}$ = 0·97 compared with 0·90 for unidentified amino-sugar and 1·05 for glucosamine), indicating that, in addition to the small amount of residual glucosamine, the unidentified amino-sugar was present in the filtrates[8]. This was confirmed by paper chromatography. The evaporated filtrates were chromatographed using tertiary butanol/6 *N* hydrochloric acid/water in the volume ratio 70 : 1 : 29 as ascending solvent (16 hr.) on papers containing glucosamine and unidentified amino-sugar. The dried papers were sprayed with ammoniacal silver nitrate and heated. Both polysaccharide samples formed spots which corresponded with unidentified amino-sugar.

The amounts of αε-diaminopimelic acid and unidentified amino-sugar detected in the polysaccharide of *B. anthracis* indicate that the whole of the

peptide moiety of the polysaccharide could be composed of the so-called 'cell wall peptide'. The presence of αε-diaminopimelic acid and unidentified amino-sugar in the polysaccharide suggest that the cell wall of *B. anthracis* consists—in part at least—of a compound of the polysaccharide and the 'cell wall peptide'. In this connexion it is recalled that a preparation from *Bacillus* '*M*' described by Guex-Holzer and Tomcsik[9] contained αε-diaminopimelic acid, unidentified amino-sugar, galactose and glucosamine as well as large quantities of phosphorus, although rigorous tests for homogeneity of the preparation were not described.

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[1] Tomcsik, J., Symp. Soc. Gen. Microbiol., **6**, Bacterial Anatomy, 41 (1956).
[2] Ivanovics, G., *Z. Immun. Forsch.*, **97**, 402 (1940).
[3] Strange, R. E., and Belton, F. C., *Brit. J. Exp. Path.*, **35**, 153 (1954).
[4] Smith, H., and Zwartouw, H. T., *Biochem. J.*, **63**, 447 (1956).
[5] Cummins, C. S., and Harris, H., *Biochem. J.*, **57**, 32 (1955); *J. Gen. Microbiol.*, **13**, 3 (1955).
[6] Strange, R. E., and Powell, J. F., *Biochem. J.*, **58**, 80 (1954).
[7] Rhuland, L. E., Work, E., Denham, R. F., and Hoare, D. S., *J. Amer. Chem. Soc.*, **77**, 4844 (1955).
[8] Strange, R. E., and Dark, F. A., *Nature*, **177**, 186 (1956).
[9] Guex-Holzer, S., and Tomcsik, J., *J. Gen. Microbiol.*, **14**, 14 (1956).

A Pasture Response to Sodium Tungstate on a New Zealand Soil

In an investigation of an apparent superiority of basic slag over superphosphate in stimulating pasture growth on a yellow-grey earth of the Warepa series (Otago Province), slag-treated plots were compared in 1951 with plots receiving superphosphate, (1) alone, (2) plus ½ oz. sodium molybdate, (3) plus 2½ oz. molybdate and (4) plus 1 lb. ammonium metavanadate per acre. Molybdenum application at both rates markedly increased pasture production, notably through the clovers, while vanadium had no effect. In September 1953 sodium tungstate (molybdenum content < 0·1 p.p.m.) was applied over one block of the experiment at 1 lb./acre. The superphosphate plot with no applied molybdenum and that with vanadium responded greatly, particularly in white clover growth, that with ⅛ oz. sodium molybdate responded slightly, while the plot treated with the heavier rate of sodium molybdate showed no additional effect from tungsten[1]. The implication was that tungsten could assume the role of molybdenum, presumably in nitrogen fixation by *Rhizobia*. A replicated trial studying the interactions of molybdenum, tungsten and vanadium, applied in proportion to their atomic weights (sodium molybdate 2½ oz./acre), has now been run on the same soil type. The trial was laid down on March 24, 1955. In the five yield cuts so far taken covering the period August 10, 1955–February 28, 1956, vanadium has had no influence either by itself or in conjunction with molybdenum or tungsten. It can therefore be disregarded in considering the molybdenum × tungsten interaction. Results are exemplified by data from the second yield cut in the tungsten × molybdenum interaction table (Table 1).

Table 1. Yields of Dry Matter lb./acre, October 13–November 10, 1955

	No tungsten	Tungsten	Mean
No molybdenum	770	940	850
Molybdenum	1,120	1,070	1,100
Mean	940	1,010	

Sig. diff.: 5 per cent. 100; 1 per cent. 130.
Molybdenum × tungsten interaction significant at 1 per cent level.

There is a significant response to tungsten only in the absence of molybdenum. In the presence of tungsten in the above cut, response to molybdenum just achieves significance at the 1 per cent level. Two further yield cuts gave similar results while the interaction in the first and fourth was not significant. Over the whole period of 6½ months both molybdenum alone and molybdenum plus tungsten gave a 27 per cent increase in dry matter production; tungsten in the absence of molybdenum a 16 per cent increase.

In an accompanying trial, rates of sodium tungstate at 1, 2, 4, 8 and 16 oz. per acre were compared. By the third cut all rates were giving significant increases in yield of pasture, amounts above 4 oz./acre conferring no extra advantage. In the fifth cut yields were recorded increasing up to, but not beyond, the 8-oz. level.

Tungsten is probably acting as a substitute for molybdenum in its role in nitrogen fixation, but less effectively. Heavier applications, at least initially, have shown no advantage; if tungstate merely freed soil molybdate held in an unavailable form one would have expected the reverse to hold. Moreover, the anion exchange effect of the far heavier basal application of phosphate (2 × 3 cwt. superphosphate) would have tended to mask any such action.

Bortels has directed attention to tungsten and vanadium having an effect similar to, but much smaller than, molybdenum in stimulating nitrogen fixation by blue-green algæ of the genera *Anabaena* and *Nostoc*[2]. In Bortels's studies with *Azotobacter* spp. and *Clostridium butyricum*[3] tungsten increased effects of vanadium and, to some extent, of sub-optimal amounts of molybdenum, the former observation prompting the trial of tungsten in the present instance.

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[1] Davies, E. B., and Grigg, J. L., *Proc. N.Z. Soc. Anim. Prod.*, **15**, 86 (1955).
[2] Bortels, H., *Arch. Microbiol.*, **11**, 155 (1940).
[3] Bortels, H., *Z. Bakt. Parasitenk* II, **95**, 193 (1936).

Phosphine as a Phosphatic Fertilizer

Since ammonia gas has been highly satisfactory as a nitrogenous fertilizer it is surprising that there is no record of any experimental work on its analogue phosphine as a source of plant phosphorus. Phosphine has many obvious disadvantages; but the fact that it is more than ten times as concentrated as superphosphate, our standard arable phosphatic fertilizer, surely merits some consideration. Commercial handling may not present any more serious problems than did some of the modern phosphorus insecticides.

A preliminary glasshouse experiment on radishes and wheat showed that phosphine was not toxic to germination or growth at normal dressings and only at a rate equivalent to 18 cwt. per acre of superphosphate was some leaf discoloration noticed. Soil retention of the compound was nothing like so efficient as with ammonia ; but at all normal dressings no loss to the atmosphere should be experienced.

In a 5 × 5 latin square glasshouse experiment with radishes where superphosphate was applied at 0, 1½ and 3 cwt. per acre and phosphine at the same levels of phosphorus there was no significant difference in the response of either total fresh matter or dry matter between the two sources of phosphorus. At the higher levels, however, the uptake of phosphorus from phosphine was very highly significantly ($P < 0.001$) better than and almost double that from superphosphate. This suggests that soil fixation may be lower with phosphine than superphosphate, and it is proposed to investigate this matter further.

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Occurrence of Peroxidase in Tension Wood of Angiosperms

Tension wood in angiosperms can be readily induced by bending stems and branches from their normal orientation, when it develops usually on the upper side of the stem or branch, in the form of a dense band (compact type), or in groups of fibres or isolated fibres scattered among the normal fibres of the tissue (diffuse type). Tension wood fibres are characterized by the fact that the fibre walls are partially or wholly unlignified[1]. The formation of tension wood thus involves a differential lignification of the xylem on the two sides of the stem or branch.

In investigations into the nature of lignification, the work of Freudenberg *et al.*[2,3], and of Siegel[4] has shown that the mechanism most probably involves oxidation of a phenyl propane type precursor by an oxidase, phenoloxidase or peroxidase. In conifers the seasonal variation in peroxidase in the zone of differentiating xylem was studied by Manskaya[5] and found to be inversely related to the coniferin content of the tissue. From this it was concluded that coniferin may form a substrate for the peroxidase, during lignification.

To examine the nature of the asymmetry of lignification in stems forming tension wood, the peroxidase distribution was studied. The method of McJunkin[6] using benzidine and hydrogen peroxide was employed to determine the peroxidase distribution. In the zone of tissue including the cambium no peripheral variation in the amount of peroxidase in stems of *Eucalyptus goniocalyx* and *Eucalyptus cladocalyx* could be seen. However, in the mature tension wood intense peroxidase activity was observed in the unlignified region of the fibre cell walls. This is illustrated in a band of tension wood of *E. goniocalyx*, shown in Fig. 1, where the area of peroxidase activity appears dark. Similar activity was observed in the fibre walls of tension wood of the diffuse type. The peroxidase reaction was not

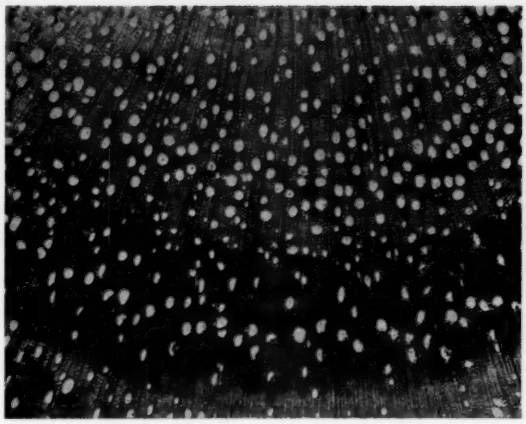

Fig. 1. *Eucalyptus goniocalyx*. A transverse section of a young stem containing a compact band of tension wood, after staining for peroxidase. (× 90)

obtained if the sections were first treated with cyanide. Addition of hydrogen peroxide to the tissue did not result in the formation of any lignin-like substances. It thus appears that the failure of tension wood to lignify may result from the differential formation of the lignin precursor on the two sides of the stem. Alternatively the change in cell metabolism resulting in the formation of highly crystalline cellulose in the cell wall may fail to provide sites to which the lignin synthesized can link, since in lignified cells lignin appears to be associated with the non-cellulosic fraction of the cell wall[7].

Further investigations are in progress.

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[1] Wardrop, A. B., and Dadswell, H. E., *Aust. J. Sci. Res.*, B, **1** (1), 3 (1948) ; *Aust. J. Bot.*, **3** (2), 177 (1955).
[2] Freudenberg, K., and Heimberger, W., *Chem. Ber.*, **83** (6), 519 (1950)
[3] Freudenberg, K., Reznik, H., Boesenberg, H., and Rasenach, D., *Chem. Ber.*, **85**, 641 (1952).
[4] Siegel, S. M., *Physiologia Plantarum*, **6**, 134 (1953) ; **7**, 41 (1954) ; **8**, 20 (1955).
[5] Manskaya, S. M., *Doklady, Akad. Nauk, U.S.S.R.*, **62**, 369 (1948).
[6] McJunkin, F. A., *Anat. Rec.*, **24**, 67 (1922).
[7] Brauns, F. E., "Chemistry of Lignin" (Academic Press, New York, 1952).

Mating in Scorpions

The courtship dance of the scorpion has been observed and recorded repeatedly since 1810 when Maccary[1] first described it. The actual conclusion of this elaborate behaviour pattern has, however, only been surmised from circumstantial evidence. For example, both Fabre[2] and Brongniart and Gaubert[3] report that scorpions were surprised beneath stones "accouplés, ventre à ventre". Vachon[4] writes as follows : "the conclusion of these nuptial dances I have not observed, but anatomical investigation bears out the statement of early writers ; the male fertilizes the female directly in a true copulation. . . .

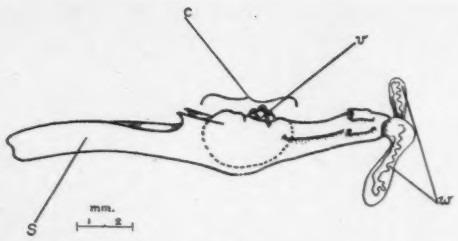

Fig. 1

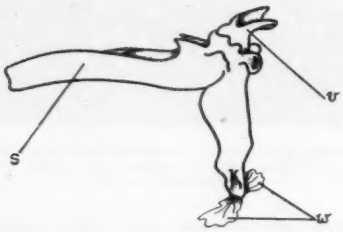

Fig. 2

In the course of this act, the male protrudes certain special organs to form a temporary penis, with which he inserts the sperm and finally places in position a vaginal plug—a kind of post-nuptial hymen".

Now it is known[5] that pseudoscorpions go through a courtship which is in many respects like that of the scorpions. During this, the male deposits on the ground a spermatophore from which the female removes the sperm mass. Lawrence[6] says, "it may be surmised that the mating act in scorpions and pedipalpi . . . follows the same general lines as that of the pseudoscorpions".

In the scorpion, *Opisthophthalmus latimanus typicus* C. Koch, the courtship has been observed repeatedly and will be described in detail elsewhere. Suffice it to say that the classical "arbre droit" is either absent or only fleetingly present; the "promenade à deux" occurs but does not usually last longer than an hour. During this latter pattern the male holds the cheliceræ of the female and not, as has been reported for other scorpions, her pedipalps. The promenade is executed over a very limited area; when the animals are performing on rough ground the male clears the soil particles from the space in which the pair are dancing but if the ground is smooth he does not show this behaviour.

In two cases recently observed in this laboratory the courtship continued to the consummatory act and the fertilization of the scorpion was witnessed. Shortly after the beginning of the promenade the genital operculum of the female was seen to be open; a little later that of the male opened as the extrusion of a spermatophore began. During the extrusion the pair continued to move backwards and forwards in the manner typical of the "promenade à deux", but with more limited excursions. As soon as the spermatophore (Fig. 1) was clear of the genital aperture of the male, he moved back slightly so that it lay free on the ground beneath him. After a few seconds he began to jerk the female violently, drawing her over the spermatophore and half-lifting her at the same time. This pattern contains the "back and forward" movement characteristic of the promenade, but the female was gradually drawn forward to a position over the spermatophore. She appeared to drop down suddenly over the capsule of the spermatophore (Fig. 1, *c*) and almost immediately rose again with the opened valves (Figs. 1 and 2, *v*) inserted into her genital aperture. The wings (*w*) were seen to be holding one end of the spermatophore firmly to the ground while the stalk (*s*) was bent through a right angle and pointed towards the male.

The two animals stood immobile for about five minutes in this attitude, the male holding the female, who held the valves of the spermatophore capsule inside her genital aperture.

The male then began to make slight retreating movements which the female appeared to resist. Suddenly the male released the cheliceræ of his partner and clutched at her with his claws, spreading his pedipalps widely. He brought his tail over and thrust his sting at her back though he did not actually insert it into her body. She responded by moving off backwards so that she was torn free of the empty spermatophore, which was left sticking to the ground (Fig. 2). The male drove her about 25 cm. from the spermatophore; she made no attempt to sting him but clutched rather feebly at him with wide-spread pedipalps. The male then turned round, rushed away and took cover.

The female moved about slowly for 30 sec. or so with her genital aperture pressed to the ground as if searching for something. When she passed over the spermatophore she ignored it. She made chewing movements with alternate cheliceræ, then suddenly appeared to lose interest in her 'search' and hurried off to cover.

Within an hour the male was observed to react favourably to another female; but when placed with the female that he had just fertilized, the pair fought violently until he retreated.

Thus *O. latimanus* shows no true copulation but a fertilization mechanism similar to that found in the pseudoscorpions—a fact in keeping with the general similarity of their genital structures, spermatophores and courtship. Furthermore, the mechanism provides a possible explanation of the "promenade à deux" of the scorpion. If the behaviour of *O. latimanus* is general for these animals, the main movement of the fertilization process is that by which the male jerks the female back and forth until she is in the correct position over the spermatophore, which she then picks up. The promenade would appear to be a prolonged intention movement of this "picking-up-the-spermatophore".

These observations were made during the tenure of a bursary awarded by the South African Council for Scientific and Industrial Research, to whom my thanks are due.

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[1] Maccary, A., "Mémoire sur le Scorpion qui se trouve la montagne de Cette", edit. 48 (Gabbon, Paris, 1810).
[2] Fabre, J. H., "The Life of the Scorpion" (Dodd, Mead and Co., New York, 1923).
[3] Brongniart, C., and Gaubert, P., *C.R. Acad. Sci., Paris*, **113**, 1062 (1891).
[4] Vachon, M., *Endeavour*, **12**, 80 (1953).
[5] Vachon, M., *Ann. Sci. Nat. Zool.*, (11), **1** (1938).
[6] Lawrence, R. F., "The Biology of the Cryptic Fauna of Forests" (A. A. Balkema, Cape Town, 1953).

'Taming' of the Wild Norway Rat by Rhinencephalic Lesions

THE common Norway rat is a wild, fierce, aggressive animal which fights with other rats or other animals, large or small, at apparently slight provocation. When captured and brought into the laboratory such rats show no diminution of their aggressive tendencies even after months or years of the comparative safety and ease of laboratory life. They escape at the slightest opportunity and are difficult to recapture. They must always be handled carefully and with heavy gloves to avoid serious injury.

Several years ago, while working in Baltimore, I initiated a study of the effects of destruction of the amygdaloid nuclei in the brains of wild and domesticated Norway rats. It was thought at the time that observations made upon two strains of the same species—one wild, fierce and intractable; the other docile, friendly and easily handled—might throw some light upon the often disputed effects of such lesions upon emotional and sexual behaviour in animals.

As a result of some incidental observations on endocrine function in some of the wild rats[1], attention was diverted and only a few domesticated rats were studied. Recently, the behaviour studies on wild rats have been repeated in a different laboratory (see present address), and it now seems worthwhile to report the striking changes in the behaviour of wild rats following the placement of lesions in the amygdaloid complex. Confirmation of the original observations has also been obtained elsewhere[2].

To date, 42 wild rats with bilateral amygdaloid lesions have been studied. Control observations have been provided by: (1) both pre- and post-operative study of the behaviour of the operated rats; (2) twelve rats which were operated unilaterally in two stages with an intervening period of several weeks or months; (3) rats which were captured at the same time as the operated animals and were kept in the laboratory under identical conditions during the life-time of the operated animals; (4) sham operated rats.

None of the control animals has ever shown any observable change in behaviour.

On the other hand, either surgical or electrolytic intervention bilaterally in the area of the amygdala has inevitably produced 'tameness' in wild rats. Although eleven rats reverted to their pre-operative aggressiveness after a few days or weeks, thirty-one remained 'tame' for long periods (up to three years).

The most striking change in the behaviour of these rats is that, immediately following the operation, they no longer bite the experimenter. As soon as they recover from the anæsthetic (ether) they can be handled without gloves and without fear of attack. Large (500–600 gm.) operated wild rats may be carried about for hours in the laboratory coat pocket without incident. They do not bite and they do not attempt to escape. Yet, they remain as alert and as active as before operation.

In addition to their behaviour with respect to handling, these rats have been observed when placed with other rats and with mice.

When white mice are introduced into a cage with normal wild rats, the mice are usually killed within a few seconds. On the other hand, wild rats with bilateral amygdaloid lesions rarely, if ever, molest the mice. In fact, they often exhibit a maternal-like grooming behaviour. This phase of the problem has been extensively studied and is reported elsewhere by Karli[2].

When wild rats are paired in the 'fighting chamber' designed by Richter[3], they fight when given mild electrical shocks on their feet. Such fights are vicious and often end in death for one of the pair. Following operation, these animals rarely, if ever, attack their partner. Their post-operative behaviour is indistinguishable from that of domesticated rats under the same conditions.

The brains of seven wild rats which remained 'tame' for three months or more have been sectioned; but none has been completely reconstructed as yet. Gross inspection and microscopical study of the sections reveal that in no brain was the amygdala completely destroyed. In all cases damage was restricted to rhinencephalic structures.

Although the precise extent of the lesion necessary to produce these changes in behaviour is as yet unknown, there seems to be little doubt that damage to the brain in the area of the amygdala produces an immediate, and in most cases permanent, loss of fierceness and aggressiveness in wild Norway rats. The mechanisms involved remain completely unknown.

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[1] Woods, James W., doctoral thesis, Johns Hopkins Univ. (1954).
[2] Karli, P., *Behavior* (in the press).
[3] Richter, C. P., *Res. Publ. Assoc. Nerv. Ment. Dis.*, **29**, 19 (1950).

Heat Regulation of MaSarwa (Bushmen)

BUSHMEN in their natural state fulfil two important criteria for acclimatization to heat[1]. They probably are unique among indigenous peoples in this regard. In the first place, they are exposed to high temperatures and fairly intense radiation. Globe thermometer readings of 140° F. in the sun and 104° F. in the shade were recorded on our excursion into the Kalahari Desert. Secondly, these men are nomadic hunters, and, in tracking down and pursuing wild game, they exercise actively in these temperatures.

Four 'wild' Bushmen volunteered and were studied near Tsetsing, some 250 miles north-west of Molepolole in the Kalahari, Bechuanaland Protectorate. The experiments were conducted in a tent to eliminate the effects of direct solar radiation and of possible variations in wind velocity. In all other respects except one the routine followed closely upon that used for developing the Predicted 4-Hourly Sweat-Rate Index[2]. The exception is that mouth and not rectal temperatures were measured as the Bushmen refused the latter. By adding 1·2° F. ± 0·6° F., mouth temperature can be converted to rectal temperature with reasonable accuracy[3].

The small size of the Bush people compared with Europeans is made clear in Table 1. The resting metabolic rate was close to that of the Singapore naval rating[4]; but the metabolic cost of work was closer to that of the Queen's Square subjects. Hence the amount of heat to be dissipated per unit surface area by Bushmen is similar to that of Europeans. Under conditions of mild heat stress, namely, 88° F. air temperature, 72° F. wet bulb temperature and globe temperature of 92° F., which has a Sweat-Rate

Table 1

Place	No.	Height (cm.)	Weight (kgm.)	Surface area ($m.^2$)	Rest		Work	
					O_2/min.	Cal./$m.^2$/hr.	O_2/min.	Cal./$m.^2$/hr.
Singapore	12	172·1	64·3	1·76	0·283	46·82	0·951	164·01
London	16	171·0	66·0	1·77	—	54·0	—	180·0
Kalahari	4	158·4	45·5	1·44	0·220	44·21	0·897 (7 mea.)	183·6 (7 mea)

Table 2

Subject	No.	Initial temperature (° F.)	Highest working temperature (° F.)	Final temperature (° F.)	Sweat-rate	
					Actual	Per $m.^2$
Europeans (acclimatized)		98·7	—	99·2	1·2	0·678
MaSarwa	4	98·4	98·7	98·4	0·890	0·618

Index rating of 1·2 l./4 hr., Bushmen regulate successfully against heat, judging by the oral temperature responses (Table 2). The actual sweat-rate is less than that of acclimatized Europeans; but is very similar when corrected to unit surface area. Using these two criteria Bushmen in their natural state are as well adapted to this degree of heat stress as are acclimatized Europeans. More severe heat stress might bring out differences such as were observed recently between Europeans and Bantu peoples[5]. It was not possible, however, to extend the studies on this excursion.

We gratefully acknowledge a grant from the South African Council for Scientific and Industrial Research, Pretoria, which enabled us to make this study. Allan Cuzen and P. Stubbs, of the Witwatersrand Native Labour Association, gave invaluable aid.

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[1] Wyndham, C. H., Strydom, N. B., Morrison, J. F., du Toit, F. D., and Kraan, J. G., *Arbeitsphysiol.*, **15**, 373 (1954).
[2] McArdle, B., Dunham, W., Holling, H. E., Ladell, W. S. S. S., Scott, J. W., Thompson, M. L., and Weiner, J. W., R.N.P.R. Report 47/391, Medical Research Council (1947).
[3] Strydom, N. B., Morrison, J. F., Booyens, J., and Peter, J., *J. App. Physiol.*, **8**, 406 (1956).
[4] Adam, J. M., and Cague, W. S., R.N.P.R. Report 53/731, Medical Research Council (1952).
[5] Wyndham, C. H., Bouwer, W. v. d. M., Devine, M. G., and Patterson, H. E., *J. App. Physiol.*, **5**, 290 (1952).

Control of Sex Ratio in Mammals

Weir[1] selected individuals of a heterogeneous strain of mice for high and low blood *p*H and established lines averaging at *p*H 7·42 and *p*H 7·46. The sex ratio of the two lines was found to diverge from 50 : 50 to approximately 40 : 60 and 60 : 40. Acid lines produced an excess of female progeny and alkali lines an excess of males. On reciprocally crossing, Weir found that the whole of the sex ratio divergence was due to the male *p*H; the female *p*H seemed to exert no influence.

It is a matter of great interest to determine: (1) whether Weir's principle may be extended to other mammals; (2) whether blood *p*H changes occurring or induced during ontogeny are reflected in alterations of the sex ratio.

No data which directly relate blood *p*H and sex ratio, apart from Weir's, seem to be available; but in several cases it is possible to infer that the principle is operating.

(1) In man the existence of non-random influences on sex ratio has been inferred from the much-discussed data of Geissler[2]. Hewitt, Webb and Stewart[3] have found an excess of all-male, though not of all-female, sibships in a collection of English families.

That these variations could be partly due to the operation of Weir's principle is suggested by data of Heath[4]. These show a significant tendency on the part of men with a high recovery index to beget an excess of daughters. Generally, 'athletic' men deviate in this direction. While athletic exertion causes a temporary reduction in blood *p*H, it does not seem to be known whether repeated exertion induces the slight permanent lowering which may be required to influence sex ratio. Shock and Hastings[5] found variations between *p*H 7·34 and *p*H 7·45 in human blood. Individuals differed significantly from each other in regard to the acid-base balance of their blood.

(2) In cattle, data of the progeny of bulls used for artificial insemination were recorded at the Southbar Cattle Breeding Station in Scotland between 1947 and 1952. Mr. James Isbister kindly made them available to me for analysis. 37,515 calves from 32 bulls were listed; of these 18,795, that is, 50·100 per cent, were females. No less than 12 bulls deviated significantly from a 1 : 1 ratio, seven of them so far that $P<0·01$. The total heterogeneity was measured by $\chi^2_{[31]} = 123·41$; $P \ll 0·001$. This indicated that a major source of sex ratio control must lie on the paternal side. The performance of 23 bulls could be broken down into annual components; most were fairly stable, but 3 of them changed their sex ratios significantly. Again, the essential data on blood *p*H are not available, but the operation of Weir's principle should be suspected.

(3) In rats, data of Moore and Price[6] can be analysed to show that at 7,500 ft. and 9,600 ft. there was a highly significant excess of females in litters conceived after the animals had been 60 days at these stations (male, 133 : female, 180. $\chi^2 = 7·05$; $P<0·01$). At 14,260 ft. there was a significant excess of males in litters conceived after the parents had been 30 days at the station (male, 33 : female, 17. $\chi^2 = 5·12$; $P<0·05$). The latter result is expected, in that high altitude is supposed to induce alkalosis. The results at less-extreme altitudes would indicate acidosis, if Weir's principle is operating. In any event, we have here strong deviations in sex ratio under conditions where disequilibrium in blood *p*H should be expected.

Monge[7,8] describes marked changes in serum *p*H during chronic mountain sickness in man. He compares the physiological condition of men acclimatized to high altitude with that of athletes. In sheep at high altitude he claims that failure to conceive is

due to widespread occurrence of azoospermia; some rams show wide variations in seminal *p*H "which indicates that the *p*H regulating system fails at high altitude". By selecting rams for normal seminal *p*H and sperm-motility the fertility of the flocks was improved.

(4) In mice, Bittner[8] found highly significant deficiencies of males in the progenies of inbred parents reared on a 'rolled oats' diet; these deviations remained significant even when the comparison was limited to 'undepleted' litters. Diet is clearly a factor which might affect blood *p*H.

Despite the absence of direct experimentation, (1), (2) and (3) above point to the extension of Weir's principle to mammals other than mice. (1) and (3) also suggest that slight changes in blood *p*H can be induced. From (2) it appears that the conditions influencing sex ratio in some bulls are labile.

A practical system of controlling sex ratio in economically important animals might, then, be set up by: (*a*) selecting sires for the appropriate *p*H tendency; (*b*) altering the *p*H of sires by: (1) administration of drugs; (2) changes in dietary regime; (3) modifications in oxygen tension.

Analyses of the data referred to here will be published elsewhere.

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[1] Weir, J. A., *J. Hered.*, **46**, 277 (1955).
[2] Geissler, A., *Z. K. Sächs. Statist. Bureaus*, **35**, 1 (1889).
[3] Hewitt, D., Webb, J. W., and Stewart, A. M., *Ann. Hum. Genet.*, **20**, 155 (1955).
[4] Heath, C. W., *Hum. Biol.*, **26**, 337 (1954).
[5] Shock, N. W., and Hastings, A. B., *J. Biol. Chem.*, **104**, 585 (1934).
[6] Moore, C. R., and Price, D., *J. Exp. Zool.*, **108**, 171 (1948).
[7] Monge, C., *Science*, **95**, 79 (1942).
[8] Monge, C., *Physiol. Rev.*, **23**, 166 (1943).
[9] Bittner, J. J., *Nutr. Bull.* No. 2, Jackson Mem. Lab. Bar Harbor (1936).

Anharmonicity, Thermal Expansion and Thermal Resistance in a Dielectric Solid

In the limit of high temperatures ($T \gtrsim \theta$) the thermal resistance of a dielectric solid is roughly proportional to the temperature:

$$W = W_\theta T/\theta$$

Two approximate formulæ[1,2] have been proposed recently expressing W_θ in terms of equilibrium thermodynamic properties of the solid; in both formulæ W_θ is equal to the product of the square of the coefficient of the thermal expansion and an appropriate dimensional factor derived from other properties of the solid. These formulæ can easily be shown to be essentially equivalent[3], and they are found to agree with the experimental data for many simple solids[1,2,4] within an order of magnitude, although discrepancies within a factor of 3 or 4 are not uncommon.

I wish to point out that such formulæ could only be strictly valid if there were a single parameter describing completely the 'anharmonicity' of the crystal potential, such as the parameter γ introduced by Grüneisen in his theory of thermal expansion. Now in a three-dimensional lattice there is no unique Grüneisen γ, and the quantities γ_j ($= -\mathrm{d} \log \nu_j / \mathrm{d} \log V$) obtained from the frequencies ν_j of normal modes are spread over a range of values[5]. The empirically determined value of γ is usually derived from the thermal expansion observed at 'high' temperatures ($T \sim \theta$), and this parameter, γ_∞ say, is then the arithmetic mean $\overline{\gamma_j}$.

Let us consider now the special case of a lattice for which this mean vanishes; there do not seem to be any simple real solids for which this is true; but it is easy to derive simple theoretical models having this property. There will then be a negligibly small thermal expansion at the high-temperature limit, and the formulæ will therefore predict no thermal resistance. But actually there will still be anharmonic terms in the crystal potential, and these will give rise to coupling between the normal vibrations and hence in general to a finite thermal resistance. This implies that any formula of this type must break down when γ is sufficiently small; further, that too small a value will then be predicted for the thermal resistance. This is consistent with the observation of Leibfried and Schlömann[1] that approximations made during the derivation of their formula are not valid when γ is small.

Of course, even if the validity of such formulæ could be established for large enough γ there still seems no reason to expect the same factor of proportionality for different crystal structures and different types of atomic or molecular binding; this is borne out by the fairly wide variation of this factor observed experimentally even in substances of high γ values. However, the effect we have been considering may possibly be apparent in substances of low γ. The lowest γ values observed in simple dielectric crystals are those of the elements carbon (diamond), germanium and silicon, all with crystals of diamond structure: the formulæ predict about four times too small a thermal resistivity for diamond[6] ($\gamma \sim 1{\cdot}1$), and even greater disparities have been recently observed in germanium and silicon[7] ($\gamma \sim 0{\cdot}8$). Unfortunately, we have as yet no knowledge of the change of individual frequencies with volume in these elements; while it is unlikely that a spread of γ_j values could account for the whole of the discrepancy, it may be a relevant factor.

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[1] Leibfried, G., and Schlömann, E., *Nach. Acad. Wiss. Göttingen*, **11a**, 71 (1954).
[2] Dugdale, J. S., and MacDonald, D. K. C., *Phys. Rev.*, **98**, 1751 (1955).
[3] White, G. K. (private communication).
[4] White, G. K., and Woods, S. B., *Nature*, **177**, 851 (1956).
[5] Barron, T. H. K., *Phil. Mag.*, **46**, 720 (1955).
[6] Berman, R., Simon, F. E., and Ziman, J. M., *Proc. Roy. Soc.*, A, **220**, 171 (1953).
[7] White, G. K., and Woods, S. B., *Phys. Rev.*, **103**, 569 (1956).

Location of Free Electrons in Porphin Ring Complexes

Several molecules containing a porphin ring, of similar central structures, possess intermediate states when undergoing oxidation, and there has been considerable speculation on the actual nature of these transient compounds[1,2]. Most interest has probably been centred on the oxidation of hæmoglobin derivatives, and the action of hydrogen peroxide, potassium periodate and other oxidizing agents has

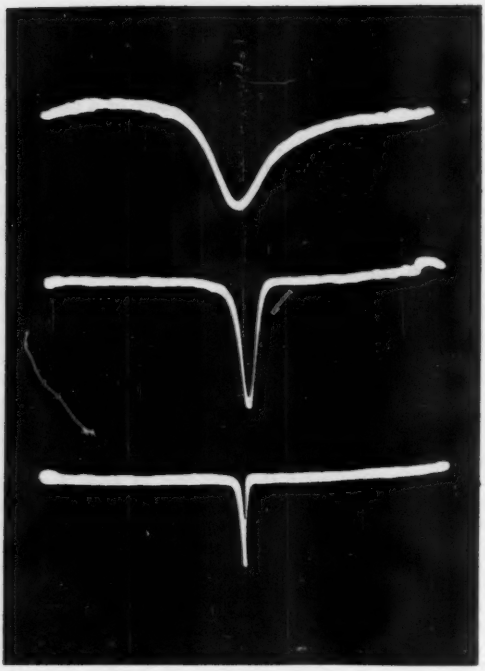

Fig. 1. Absorption lines observed from oxidation intermediates. Top, met-hæmoglobin treated with hydrogen peroxide; centre, metal-free tetra-phenyl-porphin treated with ceric oxalate; bottom, stable free radical diphenyl-picryl hydrazyl. All photographs were taken with the same field sweep

been studied in detail by George and Irvine[2]. The two possible structures for the oxidation state of the met-hæmoglobins are: (1) a radical species formed by hydrogen atom removal from some position in the conjugated ring system, or (2) a change in the valency of the central iron atom. Although several different chemical reactions were studied it was not possible to prove conclusively which of the two structures was actually present.

We have now investigated this oxidation reaction for both hæmoglobin and myoglobin by electron resonance methods, and the results show that a radical species is in fact formed with very little interaction between the unpaired electron and the central iron atom. The spectra observed can also be compared with those obtained[3] from the intermediate states formed during the oxidation of tetra-phenyl-porphin and phthalocyanine derivatives. It would appear that the orbits of the free electrons are very similar in all three cases, and embrace a considerable portion of the conjugated ring structure.

The great advantage of electron resonance techniques in such studies as these is that absorption from the unpaired electrons of the intermediate state can be observed independently of the initial and final products, and their coupling to the central metal and other atoms can be calculated from the g-value and width of the absorption line. The concentrated solution of the acid–met-hæmoglobin or myoglobin was placed in a small cup on the bottom of an H_{111} cavity[4], the oxidizing agent added and, after tuning, the whole resonator was quickly cooled in liquid air. It is possible in this way, by varying the time between addition of oxidizing agent and cooling, to study the rate of formation and decay of the intermediates. Most of the measurements were carried out at 20° K.; but the absorption lines were found to have the same width at 90° K., showing that there was no noticeable spin-lattice interaction present. Identical spectra were also observed at the two microwave frequencies employed, 25,000 Mc./s. and 36,000 Mc./s.

The absorption lines obtained from oxidized hæmoglobin and myoglobin both had a width of 25 gauss and a g-value of $2{\cdot}003 \pm 0{\cdot}001$, and a typical oscilloscope trace is shown at the top of Fig. 1. The same absorption was obtained with potassium periodate as with hydrogen peroxide, and the proximity of the g-value to that of a free electron (2·0023) is definite evidence that the oxidation state is one containing an unpaired electron mobile in the conjugated ring structure. A very similar absorption line is observed from the intermediate oxidation states of both metal-free tetra-phenyl-porphin and metal-free phthalocyanine[3]. These also have a g-value of $2{\cdot}0025 \pm 0{\cdot}0005$, with a somewhat narrower width of 9 gauss, and an example is shown in the middle curve of Fig. 1. The bottom absorption curve is that from the stable free radical diphenyl-picryl hydrazyl, with a width of 3 gauss, and acts as a comparison for the other two. The difference in width between the absorptions of the hæmoglobins and simpler porphins is probably due to exchange effects in the latter, which are absent in the hæmoglobins owing to the very large molecular size.

No hyperfine structure has been observed on any of the spectra obtained from the porphin intermediates, showing that the orbit of the unpaired electron is not confined near the nitrogens in the centre of the ring, but probably includes most of the carbon atoms. Further evidence for the mobility of the electrons in the porphin ring is also found from the hyperfine pattern observed in chlorinated tetra-phenyl copper porphin[5], where an orbit embracing the π-bonds round the ring is postulated.

It is hoped that slightly more refined techniques will allow detailed rate studies on such chemical reactions as these; but the present measurements provide conclusive evidence on the nature of the oxidation states.

J. F. Gibson
D. J. E. Ingram

University of Southampton.
Aug. 24.

[1] Cahill, A. E., and Taube, H., *J. Amer. Chem. Soc.*, **73**, 2847 (1951).
[2] George, P., and Irvine, D. H., *Biochem. J.*, **52**, 511 (1952); **58**, 188 (1954); **60**, 596 (1955).
[3] George, P., Ingram, D. J. E., and Bennett, J. E., *J. Amer. Chem. Soc.* (in the press).
[4] Ingram, D. J. E., "Spectroscopy at Radio and Microwave Frequencies", 66 (Butterworths, Ltd., 1955).
[5] Ingram, D. J. E., Bennett, J. E., George, P., and Goldstein, J. M., *J. Amer. Chem. Soc.*, **78**, 3545 (1956).

Path of the Trigatron Spark

In a recent investigation[1] into the characteristics of the trigatron[2] spark gap, an interesting effect was observed in connexion with the path taken by the spark discharge between the spherical electrodes. Several hundred discharges were observed and each spark appeared to consist of two parts. The first was a straight part along the axis of the gap and reaching from one electrode to a distance of 10–50 per cent of the gap-length. The remainder was of the familiar tortuous nature of a spark discharge. The

Fig. 1. Photograph of the spark channel in the trigatron gap. Left-hand electrode earthed; negative voltage on right-hand electrode

discharges were photographed from two directions at right angles, using mirrors and using the camera shutter in conjunction with a relay to trigger the spark. The effect occurred with regularity and was quite definite. It was found that the straight part of the spark was always that part adjacent to the anode, whatever the polarity of the high-voltage electrode. A typical photograph illustrating the effect is shown in Fig. 1, where the straight part of the spark is 20 per cent of the total gap-length.

Experimental evidence[1] supports the view that a streamer mechanism is operative in the breakdown of the trigatron gap, and a possible explanation of the effect described above is that breakdown depends on the propagation of a negative streamer, that is, from cathode to anode. When this streamer approaches the anode a positive streamer is initiated at the anode and comes out to meet the negative streamer. The streamers meet at a point in the mid-gap region, giving a change in direction of the spark path at this point. The theory would explain the straight nature of that part of the spark near the anode, since the negative streamer would constitute a conducting path; at the instant propagation of the positive streamer begins the system would thus be approximately equivalent to a very high over-voltage on a point-plane gap, and experimental observations with high over-voltages on point-plane gaps show that straight spark paths do in fact occur. Similar theories concerning change in direction of spark paths have also been given in connexion with lightning discharges, in which it is suggested that positive streamers might grow from the ground to meet the descending negative leader stroke.

A possible alternative explanation of the sudden change in direction of the spark path is that this path is modified by the presence of space charge. The spark tends to pass along the outside of the space charge rather than straight through the centre of the space charge region, where more uniform field conditions may prevail. A similar suggestion has been put forward by Howell[2] to explain the behaviour of the spark path in point-plane gaps.

T. E. Broadbent

Ferranti, Ltd.,
Wythenshawe,
Manchester.
May 30.

[1] Broadbent, T. E., Ph.D. thesis, University of Manchester (1955).
[2] Craggs, J. D., Haine, M. E., and Meek, J. M., *J. Inst. Elec. Eng.*, **93**, Pt. 3A, 963 (1946).
[3] Howell, A. H., *Trans. Amer. Inst. Elec. Eng.*, **58**, 193 (1939).

Enhancement of Ultra-violet Absorption of L-Ascorbic Acid in the Presence of D-Sorbitol

During analytical work upon certain pharmaceutical preparations of L-ascorbic acid an unusual enhancement of its ultra-violet absorption was repeatedly observed; namely, ascorbic acid in presence of various concentrations of D-sorbitol shows a considerable increase of its characteristic absorption peak both in neutral aqueous solution (*p*H 6·0) at 265 mμ and in acidic solution (*p*H 2·0) at 245 mμ.

The maxima do not shift to shorter or longer wave-lengths but the absorption curve as a whole simply behaves as if higher than actual amounts of vitamin C had been present in the solution.

Another interesting feature is the difference between the enhancement in neutral and acidic medium, which is in the former far more pronounced. This recalls a similar observation of ultra-violet absorption in irradiated solution of sugars[1]; but in our case the pure sorbitol solutions show practically no ultra-violet absorption at the concentrations examined. D-Sorbitol at *p*H 1–7 and in the presence of potassium cyanide has indeed an ultra-violet absorption of very low order which up to 10 per cent solution does not interfere with that of other solutes. The manner in which the ascorbic acid solutions have been prepared is also important; the increase can be observed only when a very concentrated solution of components of sorbitol and ascorbic acid is made at the same time. Successively, the mother solution can be diluted with water, dilute acid or dilute sorbitol until it reaches the desired final concentration and *p*H. (The diluted solution is stabilized with potassium cyanide.) In this case the reading will every time show the increase of absorption. But if, on the contrary, various amounts of pure crystalline sorbitol are added to prepared and stabilized ascorbic acid solution at a definite concentration, which is always 1 mgm. of ascorbic acid for 100 c.c. of solution, no increase will be found and the ultra-violet spectrum will remain within its normal values. There appears to be a correlation between the concentration of sorbitol and increase of absorption. Some of the values are given in Table 1.

Table 1

Conc. of D-sorbitol/100 c.c.	$E^{1\%}_{1cm.}$/265 mμ; *p*H 5·8	$E^{1\%}_{1cm.}$/245 mμ; *p*H 2·0
0·000 gm.	630	550
0·001 gm.	870	656
0·015 gm.	916	676
0·075 gm.	895	648
0·750 gm.	880	638
7·500 gm.	800	580

The reading was made on a Beckman spectrophotometer model *DU*. The solutions of ascorbic acid were controlled by potentiometric titration with dinitrophenolindophenol.

As can be seen, a maximum of increase seems to lie where the concentration of sorbitol is of 15 : 1 relation with that of ascorbic acid; but the values are too close one to another to permit the exact determination within the experimental error limits.

Undoubtedly the enhancement in neutral solution is very pronounced and reaches 48 per cent above the normal values ($E^{1\%}_{1\,cm.}$/265 mμ = 620); in acidic solution the increase is also of high order but reaches only 26 per cent ($E^{1\%}_{1\,cm.}$/245 mμ = 550). The absorp-

tion tends to decrease as the concentration of sorbitol increases and in acidic solution reaches 7·5 per cent sorbitol—almost the theoretical value. The higher concentrations of sorbitol have absorptions strong enough to begin to prevent exact reading.

It is known from the work of F. J. Bandelin and J. V. Tuschhoff[2], which was also confirmed by our experiments, that sorbitol in higher concentration exerts a marked stabilizing effect upon L-ascorbic acid in aqueous solution. But a similar effect was observed by us also with D-mannitol, which otherwise seems to have no influence on ultra-violet absorption of ascorbic acid. Thus the two effects, protective and enhancing ultra-violet absorption, cannot be readily accumulated and explained as the whole.

No definite theoretical explanation of the above phenomena can be given at present since the facts are relatively new and still under study. Further work will be done to cover other sugar derivatives and enediols at different values of *p*H, time and temperature.

The hypotheses about stabilizing effect on one of the possible forms of ascorbic acid can be tentatively put forward, although the persistence of increased absorption also in acid medium (*p*H ~ 2) is rather difficult to explain, in view of proton migration which takes place at *p*H 4.

J. S. Lawendel

Research Centre, Italfarmaco S.p.A.,
Piazza Coriolano 5,
Milan. May 18.

[1] Laurent, T. C., and Werthein, E. M., *Acta Chem. Scand.*, **6**, 678 (1952).
[2] *J. Amer. Pharm. Assoc.*, **44**, 241 (1955).

Value of the *p*F Scale for Water in an Ecological Study of an Insect living in Soil

Evans[1] demonstrated that the energy with which the soil holds water could be correlated with the loss of weight of wireworms; the energy-level was suitably expressed by Schofield's[2] *p*F scale. Evans and McL. Guild[3] then demonstrated that the rate of production and size of cocoons of earthworms were determined not by the amount of water present in the soil but by the force with which the water was held. Despite these observations the *p*F scale as a measure of available water for biological processes has scarcely been used in ecological studies of animals that live in soil. Wallace's[4] paper on the effect of hydrostatic pressure deficiency on motility of larvæ of *Heterodera schachtii* Schmidt is the only other similar study that I know.

A number of field and laboratory experiments on *Aphodius howitti* Hope, a cockchafer which inhabits sandy and loamy soils in South Australia, have suggested that oviposition is influenced by the amount of water in the soil but that expressing the results on a water-content basis for a number of soils is unsatisfactory.

The experiments were carried out with a sand and a clay loam, typical of areas in which the species is found. In one experiment beetles were confined to the two soils at various water-content levels and the numbers of eggs laid were recorded. When the results were plotted against water content of soil the numbers of eggs laid in the sand and in the clay loam could be represented by curves which were similar in form but were widely apart and hence could not be compared directly; however, when plotted against the

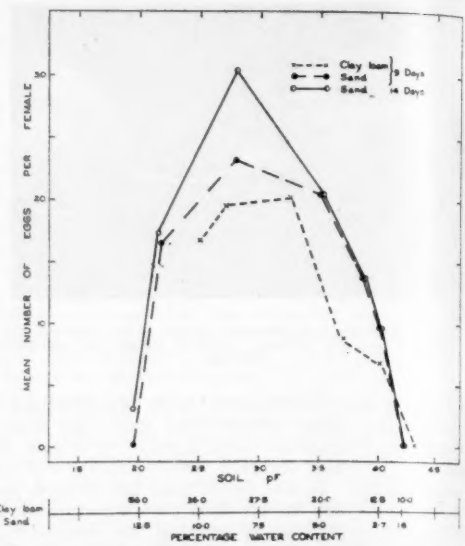

Fig. 1. The numbers of eggs laid by *Aphodius howitti* in relation to *p*F of soil. The water contents of the two soils in relation to *p*F are included for reference

*p*F of the soil water the curves were found to correspond closely (Fig. 1). It therefore appears that the ovipositional response is a function of the force with which the water is held rather than the amount of water present in the soil. The mean number of eggs in a batch did not vary significantly, the larger number of eggs laid in the range of optimum *p*F being due to more beetles laying all their eggs rather than all the beetles laying more eggs.

Beetles were then given a choice of four different levels of water content in a series of experiments with both soils. In every case the largest aggregation of beetles and eggs was recorded at a water content corresponding to *p*F 2·8, irrespective of soil type. This *p*F value also proved to be the optimum for survival of the adults.

The consistency with which *p*F 2·8 was recorded as the optimum demonstrates the usefulness of the *p*F scale for comparing the behaviour of adults in different soils.

An investigation of the absorption of water by eggs and their survival in the two soils at various water-content levels showed further that the *p*F scale could be conveniently applied to other stages of the life-cycle. An analysis of variance yielded significant differences between *p*Fs, but no significant difference between soils.

The use of the *p*F scale has led to a better understanding of the effect of water on the types of places in which *Aphodius howitti* lives and its effect on the distribution and abundance of the species in South Australia. It is probable that it could be used to similar advantage in ecological studies of other animals that live in soil.

The details of this work will be published later.

D. A. Maelzer

Waite Agricultural Research Institute,
University of Adelaide. June 15.

[1] Evans, A. C., *Ann. App. Biol.*, **31**, 235 (1944).
[2] Schofield, R. K., Trans. Third Int. Congr. Soil Sci., **2**, 37 (1935).
[3] Evans, A. C., and McL. Guild, W. J., *Ann. App. Biol.*, **35**, 471 (1948).
[4] Wallace, H. R., *Ann. App. Biol.*, **43**, 477 (1955).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 22

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE (in the Lecture Theatre of the Science Museum, Exhibition Road, South Kensington, London, S.W.7), at 5.30 p.m.—Dr. J. S. Wilkie: "An Analysis of Buffon's article *De l'Ane*, generally believed to contain the expression of his belief in a theory of evolution".

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO AND TELECOMMUNICATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m. —Informal Evening on "The Use of Transistors in Radio and Television". Talks by Dr. A. J. Biggs and Mr. E. Wolfendale.

SOCIETY OF CHEMICAL INDUSTRY, PLASTICS AND POLYMER GROUP (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. A. Höchtlen: "Polyurethanes".

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Mr. John Heaney and Mr. Martin Holdgate: "Expedition to Gough Island".

Tuesday, October 23

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. R. H. Elvery: "The Character of Concrete as an Engineering Material".*

CHADWICK TRUST (at the Royal Society of Tropical Medicine and Hygiene, 26 Portland Place, London, W.1), at 5.30 p.m.—Dr. W. Emrys Davies: "The Message of Public Health—How it Should be Told"* (Chadwick Public Lecture).

INSTITUTION OF CIVIL ENGINEERS (at Great George Street, Westminster, London, S.W.1), at 5.30 p.m.—Mr. C. G. Giles: "Skidding Resistance of Roads and the Requirements of Modern Traffic".

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT AND CONTROL SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "The Use of Electronic Computers in Nuclear Reactor Design Studies", opened by Mr. R. W. Sutton.

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.45 p.m.—"A Review of Exchange Arrangements for Engineering Students (IAESTE)". (Education Group Discussion.)

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Discussion on "Functional Efficiency of Aircraft".

Wednesday, October 24

UNIVERSITY OF LONDON (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 2 p.m.—Dr. G. Popjak: "Fat Metabolism".*

UNIVERSITY OF LONDON (at Senate House, London, W.C.1), at 5.30 p.m.—Dr. J. G. ten Houten (Wageningen): "Recent Advances in Plant Pathological Research in the Netherlands".*

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP—NUTRITION PANEL (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Debate on the motion "That in the Opinion of This Panel, Sugar is an Unnecessary Article in the Dietary".

Thursday, October 25

UNIVERSITY OF LONDON (at Goldsmiths' College, New Cross, London, S.E.14), at 5 p.m.—Prof. P. E. Vernon: "Vocational Guidance".* Third of six lectures of "Recent Pioneer Work in Education". Further Lectures on November 1, 8 and 15.)

INSTITUTE OF REFRIGERATION (at the Junior Institution of Engineers, Pepys House, 14 Rochester Row, Westminster, London, S.W.1), at 5.30 p.m.—Mr. I. F. Eyles: "Problems of Oil Separation in Refrigeration Equipment".

INSTITUTION OF ELECTRICAL ENGINEERS (in conjunction with the BRITISH NUCLEAR ENERGY CONFERENCE, at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. L. R. Blake: "Conduction and Induction Pumps for Liquid Metals".

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Sir Gavin de Beer, F.R.S.: "Science and the Humanities"* (Rickman Godlee Lecture).

Friday, October 26

ROYAL INSTITUTE OF CHEMISTRY (in the Sir William Beveridge Hall, Senate House, University of London, W.C.1), at 3 p.m.—Conference on "The Education and Training of the Chemist".

ROYAL SOCIETY OF MEDICINE, PÆDIATRICS SECTION (at 1 Wimpole Street, London, W.1), at 5 p.m.—Dr. D. V. Hubble: "Hormonal Influences on Growth" (Presidential Address).

BRITISH PSYCHOLOGICAL SOCIETY, EDUCATION SECTION (at the University of London Institute of Education, Malet Street, London, W.C.1), at 6 p.m.—Mr. W. A. Belson: "Educational and Psychological Aspects of Audience Research in the B.B.C.".

INSTITUTION OF MECHANICAL ENGINEERS, APPLIED MECHANICS AND LUBRICATION GROUPS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. G. W. K. Ford, Mr. D. M. Harris and Mr. D. Pantall: "Principles and Applications of Hydrodynamic-Type Gas Bearings".

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Sir Ronald Nesbitt-Hawes: "Educational Needs of a Technical Age"*. (Third of ten University Extension Lectures on "Technology and Industry". Further lectures on November 2, 9, 16, 23, 30, December 7 and 14.)

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. Harold C. Urey: "Diamonds, Meteorites and the Origin of the Solar System".

Saturday, October 27

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Miss Sylvia Matheson: "Time Off to Dig: an Archæological Excavation in Afghanistan".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ANALYTICAL CHEMIST (with at least a first- or second-class honours degree in chemistry, good general analytical experience and preferably a special interest in physical methods) to be deputy to the Chief Analyst—The Personnel Officer, The Radiochemical Centre, U.K.A.E.A., White Lion Road, Amersham, Bucks, quoting Ref. 649/34 (October 25).

PHYSICAL CHEMIST (with a first- or second-class honours degree in science or equivalent qualifications) IN THE TECHNOLOGICAL IRRADIATION GROUP OF THE ISOTOPE DIVISION, to study physical and chemical changes induced by radiation—The Establishment Officer, Atomic Energy Research Establishment, Harwell, Didcot, Berks, quoting Ref. 658/2 (October 25).

ASSISTANT LECTURER (preferably with special qualifications and interests in mineralogy and petrology) IN GEOLOGY—The Registrar, University College of North Staffordshire, Keele, Staffs (October 27).

CHIEF SCIENTIST (with good academic qualifications and experience in the administration of a large laboratory) in the Warwickshire Area—The Divisional Chief Staff Officer, National Coal Board, West Midlands Division, Himley Hall, Dudley, Worcs (October 27).

CHEMIST or PHYSICIST (with a first- or second-class honours degree, and preferably postgraduate experience or experience with tropical soils) AT THE RUBBER RESEARCH INSTITUTE of Malaya, Kuala Lumpur, for work on soil problems—The Secretary, London Advisory Committee for Rubber Research (Ceylon and Malaya), Imperial Institute, London, S.W.7 (October 31).

LECTURER IN MATHEMATICS—The Secretary of University Court, The University, Glasgow (October 31).

LECTURER (preferably with qualifications in organic chemistry) IN CHEMISTRY—The Registrar, Trinity College, Dublin (November 1).

LECTURER IN PHYSICS—The Secretary, The University, 38 North Bailey, Durham (November 3).

CHAIR OF CHEMISTRY in the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 8).

ASSOCIATE PROFESSOR OF PHYSIOLOGY in the Faculty of Rural Science, University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (November 12).

LECTURER IN PHYSICS—The Registrar (Room 9, O.R.B.), The University, Reading (November 12).

LECTURERS or ASSISTANT LECTURERS (2) IN METALLURGY—The Registrar, The University, Leeds 2 (November 12).

CHAIR OF CHEMISTRY in Birkbeck College—The Academic Registrar, University of London, Senate House, London, W.C.1 (November 13).

LECTURER or SENIOR LECTURER IN DENTAL BIOCHEMISTRY at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, November 15).

BOTANIST (with a first- or second-class honours degree) IN THE POMOLOGY DEPARTMENT, to work on taxonomic problems in connexion with the Institute's plant breeding work—The Secretary, Scottish Horticultural Research Institute, Mylnefield, Invergowrie, Dundee (November 17).

RESEARCH ASSISTANT AND DEMONSTRATOR (preferably with a knowledge of cytogenetics) IN THE DEPARTMENT OF BOTANY—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (November 17).

SENIOR LECTURER (preferably with qualifications in applied mathematics) IN MATHEMATICS, at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 17).

SENIOR LECTURERS or LECTURERS IN VETERINARY ANATOMY and VETERINARY MEDICINE AND SURGERY at the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 26).

BIOCHEMIST for investigational work which will include biochemical, chemical and physical analyses of tobacco from fertilizer, rotation, variety, breeding and other experiments now in progress—The Director, Tobacco Research Board of Rhodesia and Nyasaland, P.O. Box 1909, Salisbury, Southern Rhodesia (November 30).

LECTURER or ASSISTANT LECTURER (with qualifications in biology and experience in teaching) IN EDUCATION—The Registrar, The University, Leeds 2 (December 1).

LECTURER (with interests in biophysics or biochemistry) IN CHEMICAL MICROBIOLOGY—The Registrar, The University, Liverpool (December 1).

APPOINTMENTS OFFICER (with some experience and a sound scientific background) to interview applicants and recruit staff throughout the organization—Dr. B. B. Goalby, British Rayon Research Association, Heald Green Laboratories, Wythenshawe, Manchester 22.

ASSISTANT, Grade B, TO TEACH PHYSICS—The Principal, Technical College, Queen Street South, Huddersfield.

COMPUTER (under 40, with a degree in mathematics) IN THE LANDS AND SURVEY DEPARTMENT, Government of Tanganyika, for the computation of surveys of a geodetic, astronomical or cadastral nature, and the keeping of records—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.107/8/06.

ENTOMOLOGIST at the Royal Horticultural Society's Gardens at Wisley, Surrey, for duties principally advisory and instructional, but may include research work on insect pests affecting horticultural plants—The Secretary, Royal Horticultural Society, Vincent Square, London, S.W.1, marking envelope "Confidential".

FIELD OFFICER (AGRICULTURE) (aged 30/40, with sound tropical experience of experimental farm management and a knowledge of preparing and recording experiments) in the Tanganyika Government Agricultural Department—The Crown Agents, 4 Millbank, London, S.W.1, quoting M3A/43540/TA.

GEOPHYSICIST (preferably with a first- or good second-class honours degree in physics and mathematics and a background of geology) IN THE GEOLOGICAL SURVEY DEPARTMENT, for water supply work, mineral exploration and general geological survey—The Director of Geological Survey, P.O. Lobatsi, Bechuanaland Protectorate.

LECTURER IN PHYSICAL CHEMISTRY—The Registrar, Nottingham and District Technical College, Shakespeare Street, Nottingham.

METALLURGIST or METAL PHYSICIST IN THE METAL PHYSICS SECTION of the Physics Department, to lead fundamental research work on liquid and solid state problems concerned with the deformation characteristics of both single crystal and polycrystalline metals, with melting and solidification and with time-dependent processes generally —The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "M.P.I.".

RESEARCH ASSISTANT (chemistry graduate, preferably with previous analytical experience) for work on special methods of trace analysis—The Head of the Geology Department (Geochemical Prospecting Research Centre), Imperial College, London, S.W.7.

RESEARCH ASSISTANT for research in biochemistry in connexion with the central nervous system and mental disease.—The Secretary, Institute of Psychiatry, Maudsley Hospital, Denmark Hill, London, S.E.5.

RESEARCH ASSISTANT (with experimental aptitude and a sound knowledge of mathematics to G.C.E. advanced level) IN THE FLUID DYNAMICS SECTION of the Physics Department in London, to take part in the investigation of boundary layer flow and other basic problems of fluid mechanics—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "D.3".

RESEARCH FELLOW (with a research degree or research experience) IN INORGANIC CHEMISTRY, to investigate the chemistry of metal complexes of importance to biological systems—Prof. R. S. Nyholm, University College, London, W.C.1.

RESEARCH STUDENT (graduate in chemistry or biochemistry) IN THE DEPARTMENT OF CHEMISTRY, to investigate the enzymes requiring pyridoxal as co-enzyme, under the supervision of Mr. C. A. Vernon and Prof. R. S. Nyholm—Prof. R. S. Nyholm, University College, Gower Street, London, W.C.1.

SENIOR LABORATORY TECHNICIAN (male) IN THE SCIENCE DEPARTMENT, to be responsible for the Laboratories (chemistry, physics, biology), the other laboratory staff and all equipment and stock—The Principal, North-West Kent College of Technology, Miskin Road, Dartford, Kent.

SENIOR PLANT PATHOLOGIST (with a good honours degree in botany, postgraduate training in plant pathology, and practical experience of investigating the problems arising from widespread attacks of plant diseases) at the West African Cocoa Research Institute, Gold Coast, to take charge of the Pathology Division and to carry out research on virus diseases of cocoa—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.197/200/01.

SENIOR RESEARCH ASSISTANT (with a good honours degree in metallurgy or physics, practical experience, and/or research training) IN THE FACULTY OF APPLIED SCIENCE, to work in the field of creep and fatigue of ferrous materials—The Registrar, The University, Nottingham.

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REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

The First Fifty Years: a History of the Kettering and District Naturalists' Society and Field Club. (Published by the Society as a record of its work, 1905–1955.) Pp. 134. (Kettering: Kettering and District Naturalists' Society and Field Club, 1956. Copies obtainable from Mr. R. E. Leaton, Honorary Secretary, 11 Wordsworth Road, 1956.) 10*s.* 6*d.* [138

Building Research Station Digest. No. 89: Sound Insulation of Dwellings—2. Pp. 10. 3*d.* No. 90: Colourless Waterproofing Treatments for Damp Walls. Analysis of Water Encountered in Construction. Pp. 5. 3*d.* (London: H.M. Stationery Office, 1956.) [138

Wye College (University of London). Annual Report of the Department of Hop Research, 1955. Pp. 155. (Wye, Ashford, Kent: Wye College (University of London), 1956.) 5*s.* [138

Forestry Commission. Bulletin No. 26: Adelges Insects of Silver Firs. By Dr. Isaac William Varty. Pp. iv+75+70 plates. (London: H.M. Stationery Office, 1956.) 8*s.* 6*d.* net. [138

Colonial Office. Underground Storage of Grain. By D. W. Ha... G. A. Haswell and T. A. Oxley. (Colonial Research Studies, No. 2... Pp. iv+27. (London: H.M. Stationery Office, 1956.) 2*s.* 6*d.* net. [13...

Anti-Locust Research Centre. Anti-Locust Bulletin No. 23: T... Anatomy of the Red Locust (*Nomadacris septemfasciata* Serville... By Dr. F. O. Albrecht. Pp. ii+9+97 figs. (London: Anti-Locu... Research Centre, 1956.) 5*s.* 6*d.*

Ministry of Agriculture, Fisheries and Food. Fishery Investigation... Series 2, Vol. 20, No. 4: Phytoplankton and the Herring. Part... By D. H. Cushing. Pp. ii+20. (London: H.M. Stationery Offic... 1956.) 4*s.* net. [14...

The Marine Algae of New Zealand. By Prof. V. J. Chapman. (*Journ... of the Linnean Society of London*, Vol. 55, No. 360, 20 July 195... Pp. 333–502+plates 24–50. (London: Linnean Society of Londo... 1956.) 42*s.* [1...

A Bibliography of the Art of Turning and Lathe and Machine To... History, with additional reference books and periodical articles whi... are of interest in relation to these subjects. Compiled by Sydne... George Abell, John Leggat and Warren Greene Ogden, Jr. (Transl... tions by Henry Herbert Kolm.) Pp. vii+89. (Isleworth, Middx.... S. G. Abell; South Lincoln, Mass.: Warren G. Ogden, Jr., 195... Published for the Society of Ornamental Turners.) 10*s.* 6*d.*; 1.5... dollars. [2...

Guide to Evening Classes in Middlesex, Session 1956–57. Pp. 3... (London: Education Offices, Middlesex County Council, 1956.) [2...

Scottish Plant Breeding Station. Annual Report, 1956. Pp. 10... (Pentlandfield, Roslin: Scottish Society for Research in Plant Breedin... 1956.) [2...

Other Countries

Canada: Ministère du Nord Canadien et des Ressources Nationale... Division des Parcs Nationaux: Musée National du Canada. Bulleti... No. 134: La Littérature Orale en Gaspésie. Par Carmen Roy. P... v+389. (Ottawa: Imprimeur de la Reine et Controleur de la Pap... terie, 1955.) 3 dollars. [10...

Southern Rhodesia. Report of the Director, Geological Surve... for the year 1955. Pp. 12+1 map. (Salisbury: Government Printe... 1956.) [12...

United States Department of Agriculture. Technical Bulletin N... 1139: Biological Control of Insect Pests in the Continental Unite... States. By C. P. Clausen. Pp. vi+151. (Washington, D.C.: Gover... ment Printing Office, 1956.) 45 cents. [1...

Control of Johne's Disease in Cattle, Sheep and Goats. (Project N... 207.) Pp. 202. (Paris: European Productivity Agency of t... Organisation for European Economic Co-operation; London: H.... Stationery Office, 1956.) 12*s.*; 2 dollars; 600 francs. [1...

Agricultural Policies in Europe and North America—First Report... the Ministerial Committee for Agriculture and Food, May 1956. P... 372. (Paris: Organisation for European Economic Co-operatio... London: H.M. Stationery Office, 1956.) 18*s.*; 3 dollars; 9... francs. [1...

Board of Grain Commissioners for Canada. Grain Research Labo... tory, 1955 Report. Pp. vi+77. (Ottawa: Queen's Printer, 1956.) [1...

Nyasaland Protectorate. Annual Report of the Geological Surv... Department for the year ended 31st December 1955. Pp. 26. (Zomb... Government Printer, 1956.) 2*s.* 6*d.* [1...

Zoology of Iceland. Vol. 1, Part 2. Pp. 206+5 plates. Kr. 1... Vol. 1, Part 4. Pp. 36. Kr. 3.25. Vol. 1, Part 6. Pp. 45. Kr. 4.5... Vol. 2, Part 2. Pp. 79. Kr. 7.50. Vol. 2, Part 5a. Pp. 82. Kr. 7.5... Vol. 2, Part 5b. Pp. 37. Kr. 3.25. Vol. 2, Part 6. Pp. 2. Kr. 0.1... Vol. 2, Part 7. Pp. 13. Kr. 1.25. Vol. 2, Part 8. Pp. 20. Kr. 1.8... Vol. 2, Part 9. Pp. 26. Kr. 2.75. Vol. 2, Part 10. Pp. 40. Kr. 3.7... Vol. 2, Part 11. Pp. 34. Kr. 3.75. Vol. 2, Part 16. Pp. 6. Kr. 1.7... Vol. 2, Part 17. Pp. 4. Kr. 0.75. Vol. 2, Part 19. Pp. 18. Kr. 1.5... Vol. 2, Part 20a. Pp. 15. Kr. 1.50. Vol. 2, Part 20b. Pp. 10. K... 1.50. Vol. 2, Part 21. Pp. 5. Kr. 0.40. Vol. 2, Part 22. Pp. 4. K... 0.40. Vol. 2, Part 23. Pp. 16. Kr. 1.50. Vol. 3, Part 24. Pp... Kr. 1.00. Vol. 3. Part 25. Pp. 31. Kr. 3. Vol. 3, Part 26. Pp. 11... Kr. 10.50. Vol. 3, Part 27. Pp. 26. Kr. 2.75. Vol. 3, Part 28. P... 11. Kr. 1.25. Vol. 3, Part 29. Pp. 24. Kr. 2.25. Vol. 3, Part 30–3... Pp. 11. Kr. 1.25. Vol. 3, Part 32. Pp. 19. Kr. 1.85. Vol. 3, Part 3... Pp. 116. Kr. 10.50. Vol. 3, Part 34. Pp. 24. Kr. 1.50. Vol. 3, Pa... 35. Pp. 50. Kr. 4.50. Vol. 3, Part 36. Pp. 9. Kr. 0.75. Vol.... Part 38. Pp. 5. Kr. 0.40. Vol. 3, Part 39. Pp. 4. Kr. 0.40. Vol.... Part 40. Pp. 6. Kr. 0.60. Vol. 3, Part 41. Pp. 4. Kr. 0.40. Vol.... Parts 43–44. Pp. 23. Kr. 2.25. Vol. 3, Part 47. Pp. 7. Kr. 0.7... Vol. 3, Part 48a. Pp. 189. Kr. 18. Vol. 3, Parts 49–50. Pp. 17... Kr. 16.50. Vol. 3, Part 51. Pp. 21. Kr. 16.50. Vol. 3, Part 52... Pp. 29. Kr. 3. Vol. 3, Part 53. Pp. 9, Kr. 0.90. Vol. 3, Part 5... Pp. 13. Kr. 1.50. Vol. 4, Part 59. Pp. 11. Kr. 0.90. Vol. 4, Part 6... Pp. 150. Kr. 14.25. Vol. 4, Part 61. Pp. 54. Kr. 5. Vol. 4, Part 6... Pp. 5. Kr. 0.75. Vol. 4, Part 63. Pp. 116. Kr. 11. Vol. 4, Part 6... Pp. 15. Kr. 1.50. Vol. 4, Part 65. Pp. 31. Kr. 3. Vol. 4, Part 66... Pp. 3. Kr. 0.15. Vol. 4, Part 67. Pp. 11. Kr. 1.25. Vol. 4, Pa... 68–69. Pp. 2. Kr. 0.25. Vol. 4, Part 70. Pp. 67. Kr. 6.50. Vol.... Part 71. Pp. 4. Kr. 0.40. Vol. 4, Part 71b. Pp. 25. Kr. 2.... Vol. 4, Part 72. Pp. 150. Kr. 14.25. Vol. 4, Part 76. Pp. 52. Kr.... (Copenhagen: Ejnar Munksgaard, 1937–1955.) [2...

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